Fraunhofer
ITWM

FRAUNHOFER-INSTITUT FÜR TECHNO- UND WIRTSCHAFTSMATHEMATIK ITWM

ANNUAL REPORT 2008

Editorial Note

The editors wish to thank all cooperating partners for placing the corresponding photos at their disposal.

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Annual Report 2008

Fraunhofer-Institut für Techno- und Wirtschaftsmathematik ITWM

Content

Preface

The year 2008 was a further year of continuous high-level growth for the ITWM in the fields of budget and personnel. Remarkably, this growth has almost exclusively been due to increasing income from industrial projects, in spite of the current financial and beginning economic crisis. However, economic bellwethers of the first quarter of the year 2009 show that this trend will unfortunately not continue in 2009. We expect hard times this year with respect to economic returns; the crisis has meanwhile reached the ITWM, too. Several firmly planned industrial projects have already been postponed or divided into smaller and temporally staggered batch sizes. Unfortunately, these effects will not be compensated entirely by new projects indirectly due to the crisis. Among these are R&D cooperation projects for which enterprises did not have any free personnel in times of booming economy and long terms of delivery; these projects are increasingly being commissioned now.

Besides, additional investments into science, research, and innovation, initiated by the Federal government and the Länder during the past few years, will also have positive effects on the ITWM during the period 2009 – 2011; all in all, we therefore expect a further growth of the institute during the current and the next few years. The institute's continuous economic and scientific success is guaranteed by the work of all our employees. Please let me use this occasion to thank them all very much for their strong commitment and high motivation and identification with the work and the targets of the ITWM. Their ideas and competences are the vital nerve of our institute.

Since we have moved to the new Fraunhofer Center, an entire number of 100 new employees and PhD students have been hired. If we deduct those who have left the institute, we have a net growth in personnel by 30 per cent; as a result, we already have no free room capacity left at the institute. We did not anticipate such an order of magnitude during our construction planning, and are therefore especially delighted that the Land Rhineland-Palatinate and the Fraunhofer-Gesellschaft – whom I would like to thank both very much on this occasion – have examined and approved our application as to the construction of an additional building so fast. We expect the beginning of the construction works already during the autumn of the current year.

Projects with small and mediumsized enterprises and regional companies are still representing an essential percentage of the ITWM's economic returns. Noticeably, however, the share of economic returns stemming from clients from foreign countries has meanwhile increased to over 40 per cent. Globalization can still be observed in economy. Company profiles change, R&D projects are increasingly influenced by globalized scenarios, and it is expected that Fraunhofer institutes adapt their service portfolio to these developments. The main share of foreign economic returns of the ITWM comes from Scandinavia, where the ITWM is active on the market in cooperation with its partner institute, the Fraunhofer-Chalmers Centre for Industrial Mathematics in Gothenburg. Experience shows that acquisition within a European economic area is especially successful if it is supported by strategic alliances with local research institutions.

The ITWM's keystones for the successful mathematical solution of practical problems are the classical disciplines of applied mathematics. They are the necessary components for a successful transfer of mathematics to everyday practice. However, this transfer additionally requires specific competences which are in the focus of the project work and are needed in almost every larger simulation project. With respect to the processing of data made available by experiments and observations, these are: the development of the mathematical models, the transfer of the mathematical problem solutions to numerical algorithms, the integration of data, models, and algorithms into simulation software, the optimization of solutions in interaction with simulation, and finally the visualization of the simulation runs in images and graphics. These are core competences available at the ITWM for all of the mathematical disciplines mentioned above.

These competences also form the basis of the network of which the ITWM is part within the Fraunhofer-Gesellschaft, a network consisting of numerous memberships in Fraunhofer joint research groups and alliances, as well as of cooperation projects with other institutes. In many different ways, the ITWM is connected to 51 of the overall 57 Fraunhofer institutes, enormously profiting from the domainspecific know-how of its Fraunhofer-internal cooperation partners especially in the context of mathematical modeling.

The year 2008 also was the Year of Mathematics. Numerous events throughout Germany helped to make mathematics highly visible and to create a stronger foundation in public awareness than before for the role and importance of mathematics. The ITWM also contributed to this success by a number of individual initiatives and the participation in nationwide events. From our specific point of view from Kaiserslautern, the most important contribution to the Year of Mathematics with longterm effects was the "Mathematikinitiative" of the Land Rhineland-Palatinate, the Technical University of Kaiserslautern, and the Fraunhofer ITWM.

Kaiserslautern has by now become one of the leading locations in mathematics throughout Germany, which is documented by regular top positions in national rankings and numerous international cooperation projects with renowned universities and other research institutions in Europe and overseas. The "Mathematikinitiative" has decisively strengthened mathematics in Kaiserslautern and enabled the location to sustainably preserve the high quality of research, teaching, and technology transfer, in order to remain competitive on a national and international level.

The "Mathematikinitiative" is focused on the creation of five new chairs including the respective research groups, which are supposed to cover those main subjects of industrial mathematics which have not yet or only insufficiently been represented in the department up to now and are directly connected to one or more of the research areas of the ITWM. Besides, the foundation of the "Felix-Klein-Center for Mathematics" has institutionalized the connection in research and teaching between the Fraunhofer ITWM and the Department of Mathematics by covering a wide range of pure and applied mathematics. In combination with the exposed practical orientation of the ITWM, a mathematical center has been created which represents a nucleus of excellence, being exquisitely prepared for interdisciplinary research and the transfer of mathematics to economy and society. In a certain way, the name is also the program.

Many scientific institutes carry the name and follow the program of famous scientists – Max Planck and Joseph von Fraunhofer are especially convincing examples. Felix Klein (1849-1925) ideally represents the program which the "Mathematikinitiative" intends to realize in Kaiserslautern: he was an important mathematician, an innovative teacher, and – as the creator of Mathematics in Göttingen - an extraordinary organizer of science. He took care that David Hilbert, Ludwig Prandtl, and Carl Runge received chairs in Göttingen – the best "pure" mathematician providing the raw material for the models, the best scientist in fluid dynamics who has developed models which are still valid today, and the best numerical scientist whose Runge-Kutta methods are still today state of the art. In such a way, Göttingen became the "Princeton" of mathematics during the Twenties of the last century.

The interlocking with the Department of Mathematics under the roof of the Felix-Klein-Center is of supreme relevance for the ITWM – with respect to the attraction of highly qualified scientists and, which is even more decisive, as an essential component of safeguarding the institute's future by the cooperation with respect to application-oriented fundamental research.

Finally, let me say a few words considering the pictures within our annual report. After having visited the "Pfalzgalerie" and the "Pfalztheater" in the last two years, we now staged the auditorium of the Fraunhofer Center with respect to the Year of Mathematics. It is easy to recognize the hallmarks of the photo artist Thomas Brenner within the group portraits; he undertook a journey through time through the Year of Mathematics in Kaiserslautern together with our employees on site, reenacting the individual stations.

I wish you a pleasant reading of our annual report and hope that you will enjoy the pictures. We would be very pleased if you contacted our employees on the grounds of one of the projects, or if you had any proposals for cooperation yourselves. We are open for any ideas and suggestions.

Prof. Dr. Dieter Prätzel-Wolters, Director

During the Year of Mathematics, the ITWM had numerous possibilities to present itself on the occasion of internal and external events, and to make its contributions to free the image of mathematics in public from sufficiently known prejudices. Whether this objective of the scientific year 2008 has been reached will only turn out in the years to come, for example by hopefully increasing numbers of students beginning their studies in the mathematical-scientific departments at German universities. The following pages show an overview over the contributions of the ITWM to the Year of Mathematics. Besides, the institute participated in the "Wissenschaftssommer" in Leipzig and in the 4th Day of Research in Rhineland-Palatinate in Koblenz; it was also the destination of an excursion of the 99th Federal Congress of the German Association for the Promotion of Mathematical and Scientific Lessons MNU, held in March at the Technical University of Kaiserslautern.

Mathematical Modeling Weeks

The Modeling Weeks at the Department of Mathematics have already become a tradition; during the Year of Mathematics, they were also offered in Bavaria for the first time, supported by the Fraunhofer-Gesellschaft. The Modeling Weeks are intended for pupils of classes 11 and 12 interested in Mathematics, as well as for high school teachers of Mathematics. Participants work in teams on the solution of mathematical problems from industry, economy, and society, tutored by a scientific consultant. The solutions are presented at the end of the course. In such a way, pupils are offered the possibility to get insight into the manifoldness of modern Mathematics and its relation to everyday life. Teachers may use the Mathematical Modeling Week as a suggestion for their own lessons or simultaneously regard it as further professional training. The program of the Modeling Week which took place in Lambrecht in June also included an excursion to the ITWM – with the appropriate means of transport: the Year-of-Mathematics bus designed by the ITWM and the ITWM bus.

The first Bavarian Modeling Week took place at the youth hostel in Garmisch-Partenkirchen at the beginning of October. It was supported by the Fraunhofer-Gesellschaft and organized by scientists of the Fraunhofer ITWM and the Departments of Mathematics of the Technical Universities of Kaiserslautern and Munich.

Exhibition "Imaginary – with the Eyes of Mathematics"

During March and April 2008, we presented the exhibition "Imaginary – with the Eyes of Mathematics". The traveling exhibition organized by the Mathematical Research Institute in Oberwolfach showed the aesthetic and visual component of mathematics, explaining the theoretical background of 3d objects, virtual worlds, and interactive installations. More than 2,000 visitors have come to see "Imaginary", among those many school classes.

ITWM exhibits on the "MS Wissenschaft"

The exhibition boat of "Wissenschaft im Dialog" was on the way in 2008 as a "mathematical boat". In 31 cities, more than 118,000 people visited the MS Wissenschaft – more visi- tors than ever before. The Fraunhofer ITWM was represented on the boat by two interactive exhibits: "Floodwater Simulation" (in cooperation with the Fraunhofer SCAI) and "Defect Detection on Cow Skins" from the field of surface inspection. On board of the MS Wissenschaft, visitors of the exhibition could test whether they were able to detect defects as precisely as the software: the monitor shows a cow skin with irregularities; these can be selected and marked by a joystick. Finally, the computer compares the result with the automatically found solution.

Competition "Mathematik bewegt – steig' ein"

From April until November, the ITWM, the Department of Mathematics of the Technical University of Kaiserslautern, and the Technische Werke Kaiserslautern (TWK) organized a "bus competition" entitled "Mathematik bewegt – steig' ein". Every month, posters in the 60 buses of the TWK announced a new competition round. Participation tickets with mathematical optimization problems somehow connected to the city of Kaiserslautern were available to take away in the buses. The competition was primarily intended for mathematical amateurs. During the seven competition rounds, prizes with an overall worth of more than 7,000 Euros were raffled off among the participants every month. The most interesting solutions were published on www.mathematik-bewegt.de.

Runde 1: Ist der FCK zu retten?

Wir schreiben den 26. April 2008. Vier Spieltage vor Schluss der Saison 2007/2008 der 2. Bundesliga gibt es in Kaiserslautern nur ein Gesprächsthema: Ist der FCK zu retten?

Da er ja in den noch ausstehenden vier Spielen 12 Punkte holen kann, scheint dies machbar zu sein, aber stemmt das wirklich? Kann er aus eigener Kraft heraus die Klasse halten?

Was muss passieren, damit der FCK die Liga erhält? Wie viele Punkte braucht der FCK mindestens? Gibt es eine „magische Punktgrenze x", so dass alle Vereine, die mindestens x Punkte erreichen können, theoretisch den Abstieg noch abwenden können?

Die noch ausstehenden Spiele lauten wie folgt:

31. Spieltag
1860 München – Freiburg
Mainz – Kaiserslautern
St. Pauli – Aue
Greuther Fürth – Paderborn
Jena – Osnabrück
Offenbach – M'Gladbach
Aachen – Augsburg
Koblenz – Wehen
Köln – Hoffenheim

32. Spieltag
Osnabrück – Greuther Fürth
Paderborn – 1860 München
Aue – Jena
Kaiserslautern – St. Pauli
Mainz – Aachen
Augsburg – Köln
Hoffenheim – Koblenz
Freiburg – Offenbach
M'Gladbach – Wehen

33. Spieltag
Köln – Mainz
St. Pauli – Aachen
M'Gladbach – Freiburg
Jena – Kaiserslautern
Greuther Fürth – Augsburg
Koblenz – Aue
Wehen – Paderborn
Offenbach – Hoffenheim
1860 München – Osnabrück

34. Spieltag
Paderborn – M'Gladbach
Hoffenheim – Greuther Fürth
Aue – 1860 München
Kaiserslautern – Köln
Aachen – Koblenz
Augsburg – Jena
Osnabrück – Offenbach
Freiburg – Wehen
Mainz – St. Pauli

Hypothetische Tabelle vier Spieltage vor Saisonende

Platz	Verein	Spiele	Tore	Punkte
1	Borussia M'gladbach	30	58:29	61
2	SC Freiburg	30	43:30	56
3	1. FSV Mainz 05	30	48:27	51
4	1. FC Köln	30	51:36	51
5	1899 Hoffenheim	30	42:30	51
6	TSV 1860 München	30	39:30	44
7	TuS Koblenz	30	32:35	40
8	SpVgg Greuther Fürth	30	47:35	39
9	SV Wehen Wiesbaden	30	39:41	39
10	FC Augsburg	30	35:41	37
11	VfL Osnabrück	30	39:48	36
12	Kickers Offenbach	30	32:47	36
13	FC St. Pauli	30	35:45	35
14	Alemannia Aachen	30	37:46	34
15	FC Carl Zeiss Jena	30	40:49	32
16	1. FC Kaiserslautern	30	26:30	31
17	FC Erzgebirge Aue	30	35:46	30
18	SC Paderborn 07	30	16:41	19

Mathematik
Alles, was zählt

Exhibition "A Mathematical Art Book – an Artistic Mathematics Book"

In August and September, the exhibition "A Mathematical Art Book – an Artistic Mathematics Book" of the engineer and artist Franz Xaver Lutz was shown at the ITWM. In his works, the artist builds a bridge between arts on the one side and mathematics and biology on the other side. He gets inspired by the richness of mathematical relations and shapes in nature, showing in his images how aesthetic shapes especially in biology are connected to the respective mathematical constructions. The exhibition was a project of the Klaus Tschira Foundation, which primarily supports research projects in applied informatics, natural sciences, and mathematics.

Open Doors at the Fraunhofer ITWM

At the end of September, the ITWM opened its doors to more than 800 visitors, who came to enjoy culture and science. We offered lectures, software demonstrations, films about the work of the mathematicians in Kaiserslautern, as well as guided tours through the building, music, a satirical show, and readings; there was a comprehensive children's program, too.

The Profile of the Institute

Computer simulations have become an indispensable tool for the design and optimization of products, services, and communication and working processes.

Real models are substituted by virtual models. As a raw material for the models and a key technology for computer simulations, mathematics represents the foundation of the bridge towards the world of simulation, which has been established in almost every field of society and economy. An increasing number of small and medium-sized enterprises use simulation for cost reduction. The Fraunhofer ITWM especially supports these companies by consulting and computer performance. The companies are profiting on the market due to the application of simulations as a sign for innovation and quality assurance of their products. Of course, we are also cooperating with large enterprises, mainly in the fields of automobile construction, engineering, textile industry, microelectronics, banks, and computer industry.

We meet complex challenges in technology, logistics, communication, and finances by the application of modern mathematical methods and we are also further developing applied mathematics by innovative ideas, creating practical solutions in cooperation with industrial partners. Integral components of these solutions are consulting with respect to R&D problems, support with respect to the application of high performance computer technology, and the development of especially tailored software solutions.

The intention of the ITWM is not only to build the bridge between the real and the virtual world, but also to provide a connection between mathematical research at the universities and the practical application of the results. Close cooperation with the Department of Mathematics of the Technical University of Kaiserslautern is therefore especially important for the ITWM. The Fraunhofer ITWM is one of the leading partners for mathematics in industry. We intend to strengthen and expand this position.

Competences and main research subjects

Transport Processes
- flexible structures
- flow
- grid-free methods
- heat, diffusion, radiation
- model reduction

Flow and Material Simulation
- microstructure simulation and virtual material design
- hydrodynamics
- complex fluids
- structure optimization in mechanics and acoustics

Image Processing
- microstructure analysis
- surface inspection
- signal analysis (railway)
- ultrasonic imaging

System Analysis, Prognosis and Control
- dynamic heterogeneous networks
- monitoring and control
- decision support in medicine and technology
- prognosis of material and product properties
- multiscale structure mechanics

Optimization
- optimization of company structures and processes
- optimization in medical therapy planning
- optimization in virtual engineering

Financial Mathematics
- credit derivatives
- credit risk

- option pricing
- portfolio optimization and interest rate structure models
- insurance mathematics

Mathematical Methods in Dynamics and Durability

- component properties depending on the casting process
- modeling and simulation of mechatronic systems
- durability (MBS, FEM, lifetime)
- statistical methods in operational strength

Competence Center High Performance Computing

- service-oriented computing
- nano-scale process modeling
- parallel algorithms, performance analysis
- processing of seismic data
- Cell Competence Center
- visualization of large amounts of data

Fraunhofer Chalmers-Research Centre for Industrial Mathematics FCC

- geometry and motion planning
- computational engineering and design
- risk management
- systems biology and bioinformatics

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Mathematics to go: the flexible structure constructed of quarters of circular arcs called "tangle" is a toy which the visitors of the numerous events of the Scientific Year will be able to play with for a long time, tangling and disentangling it. The color of the Year of Mathematics was orange, to be seen not only on the tangle, but also on the logo, on flags, on posters, on numerous flyers, and on the websites. The nationwide campaign of the Scientific Year had the motto "You know more of Mathematics than you know."

Costumers and Cooperation Partners

For many years now, the ITWM has successfully cooperated with enterprises from many branches and of different sizes. In the year 2008, these were, among others

- ABB Schweiz AG, Baden (CH) und Dättwil (CH)
- ABB Västerås (S)
- Adam Opel AG, Rüsselsheim
- Alfred-Wegener-Institut für Polar- und Meeresforschung, Bremerhaven
- Angell-Demmel Europe GmbH, Lindau
- Argo Hytos GmbH, Kraichtal-Menzingen
- Assenagon GmbH, München
- AUDI AG, Ingolstadt
- Ballard Power Systems Inc, Burnaby (CDN)
- BASF Chemical Company, Ludwigshafen
- Bayerisches Zentrum für Angewandte Energieforschung e.V., Würzburg
- Bergen Oilfield Services, Bergen (N)
- Biotronik GmbH & Co. KG, Technologie- und Servicezentrum, Erlangen
- BPW Bergische Achsen, Wiehl
- Burgmann Industries GmbH & Co KG, Wolfratshausen
- Commissariat á l'Energie Atomique CEA, Saclay (F)
- Daimler AG, Stuttgart, Sindelfingen und Wörth
- Deutsche Apotheker- und Ärztebank, Düsseldorf
- Deutsche Rockwool Mineralwoll GmbH, Gladbeck
- Deutsches Krebsforschungszentrum, Heidelberg
- DEVnet GmbH & Co. KG, Augsburg
- DuPont, Wilmington (USA)
- EADS Deutschland GmbH, Ottobrunn
- Ecole des mines, Paris / Fontainebleau (F)
- EKF diagnostic sales GmbH, Barleben
- Universities of Applied Scienes: Aalen, Amberg-
  Weiden, Aschaffenburg, Darmstadt, Emden, Kaiserslautern, Köln, Landshut, Südwestfalen, Wiener Neustadt, Westküste, Worms, Zwickau
- Fleetguard Filters Pvt. Ltd., Pune (IND)
- Fraunhofer-Chalmers Research Centre for Industrial Mathematics FCC, Göteborg (S)
- Friedrich-Miescher-Laboratorium für biologische Arbeitsgruppen in der MPG, Tübingen
- Fritz Stenger GmbH, Heimbuchenthal
- GE Transportation Systems, Bad Dürkheim
- Germanischer Lloyd AG, Hamburg
- Gienanth GmbH, Eisenberg
- GM Powertrain, Rüsselsheim
- Gruber NaturHolzHaus, Rötz
- Gumpp & Maier, Binswangen
- Harvard Medical School, Cambridge (USA)
- HegerGuss GmbH, Enkenbach-Alsenborn
- Honda R&D Co., Ltd., Tochigi (JP)
- Hydraulik-Ring GmbH, Nürtingen
- HypoVereinsbank, München
- IBM Deutschland, Böblingen
- IBS Filtran, Morsbach
- Ikon Science, Teddington (GB)
- Indian Institute of Technology, Madras (IND)
- Infineon Technologies AG, München
- Infracom Italia, Padua (I)
- Institute for Parallel Processing, Bulgarian Academy of Science, Sofia (BG)
- International Partners in Glass Research (IPGR), Cham (CH)
- John Deere, Zweibrücken und Mannheim
- Johns Manville Europe GmBH, Bobingen
- Keiper GmbH & Co. KG, Kaiserslautern und Rockenhausen
- Kliniken: Frankfurt-Hoechst, Heidelberg
- Kreissparkasse Kaiserslautern
- Landesbank Baden-Württemberg, Stuttgart
- M+W Zander, Stuttgart
- MAGMA Gießereitechnologie GmbH, Aachen
- Mann + Hummel GmbH, Ludwigsburg
- Massachusetts General Hospital (MGH) / Harvard Medical School, Boston (USA)
- Max-Planck-Institute: Biologische Kybernetik, Tübingen; Informatik, Saarbrücken; Mathematik in den Naturwissenschaften, Leipzig; Molekulare Genetik, Berlin; Plasmaphysik, Garching
- MTU Aero Engines GmbH, München
- NOGRID GmbH, Mainz
- Noil Energy ASA, Oslo (N)
- Noreco ASA, Stavanger (N)
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- proALPHA Software AG, Weilerbach
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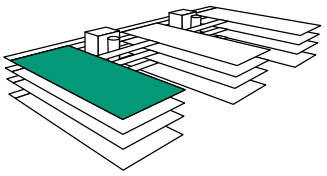

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	Financial Mathematics	Priv.-Doz. Dr. Marlene Müller	0631/31600-43 46
	Mathematical Methods in Dynamics and Durability	Dr. Klaus Dreßler	0631/31600-44 66

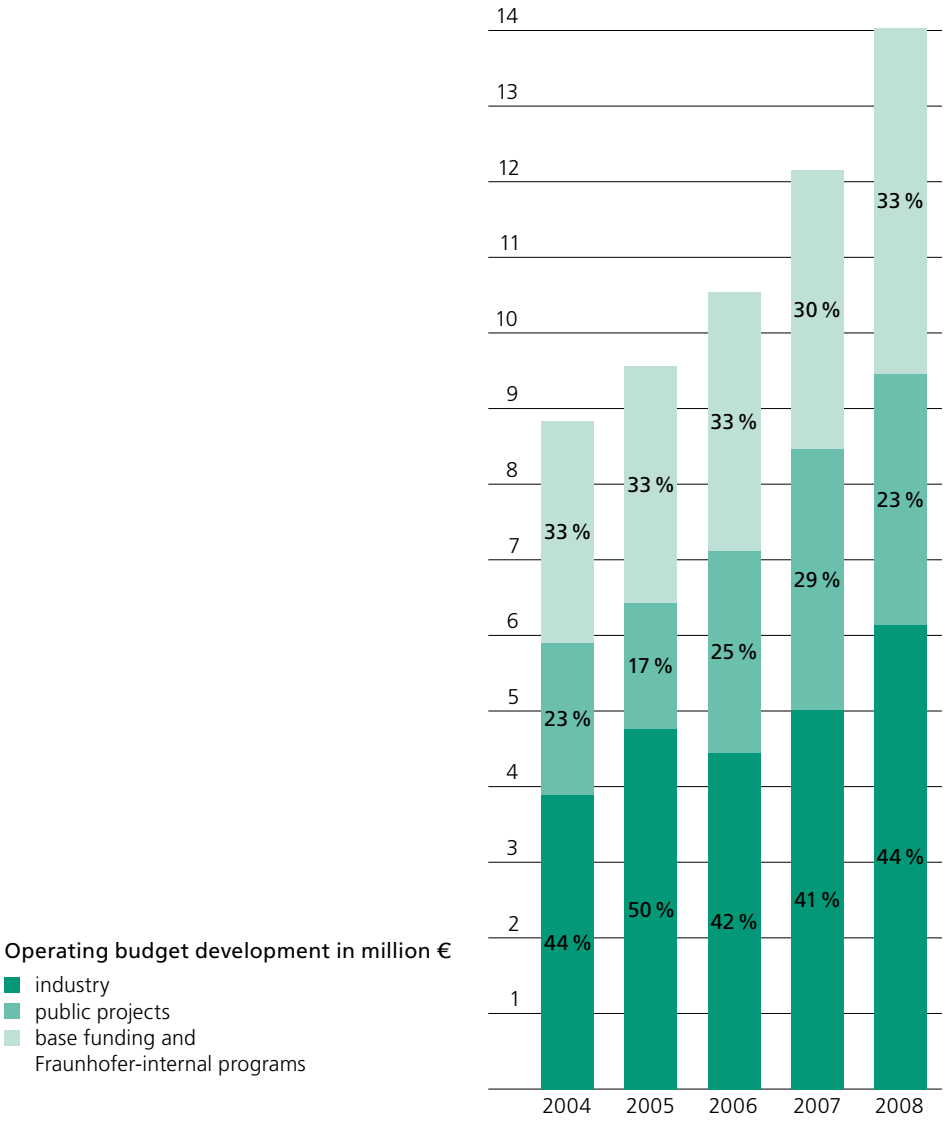
Budget

During the financial year 2008, the institute was once more able to increase the successful numbers of 2007, confirming these on a high level. As in the previous year, the growth rate of the operating budget again amounted to over 15 per cent. The growth of the operating budget was significantly also due to the new regulations considering research allowances, a possibility of which the ITWM made full use of in order to reward the high commitment of its employees.

Overall returns increased by almost 11 per cent. In spite of the beginning economic crisis during the last two quarters of 2008, returns from industrial projects increased by an extraordinary 22 per cent to an overall sum of almost 6.2 million Euros, the relative change thus amounting to 44 per cent. Remarkably, 40 per cent of economic returns meanwhile come from projects in cooperation with companies from foreign countries, especially from Scandinavia. Of course, this is also evidence of the fact that the strategic alliance with the Fraunhofer-Chalmers Centre for Industrial Mathematics in Gothenburg is now bearing fruit. Projects with small and medium-sized enterprises and regional companies also still represent an essential percentage of the ITWM's economic returns.

Concerning the returns from publicly funded projects, the ITWM still is very successfully being supported by the Germany Ministry for Education and Research BMBF. Although means for special mathematical programs are almost inexistent, the extraordinarily wide range of applications of mathematical methods in almost every area has been decisive. The ITWM continues to be a sought-after cooperation partner for enterprises and research institutes from many areas. With respect to publicly funded projects, the ITWM expects further growth rates for 2009. Already at the beginning of 2009, several larger projects funded by Federal ministries were approved. We can thus expect that we will insofar be able to manage the year of crisis 2009 and to compensate the decrease of economic returns, which is to be expected and already showing.

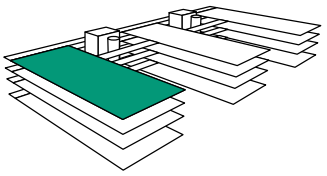
Nevertheless, the ITWM is looking optimistically towards the future, trying to remain competitive and to strengthen its successful position on the market by developing new areas of competence and intensifying mathematical research in promising application areas.



Operating budget development in million €

- industry
- public projects
- base funding and Fraunhofer-internal programs

Budget development (thousand €)	2004	2005	2006	2007	2008
Operating budget	8844	9560	10550	12163	14035
Investments	376	499	332	1720	383
Total	**9220**	**10059**	**10882**	**13883**	**14418**

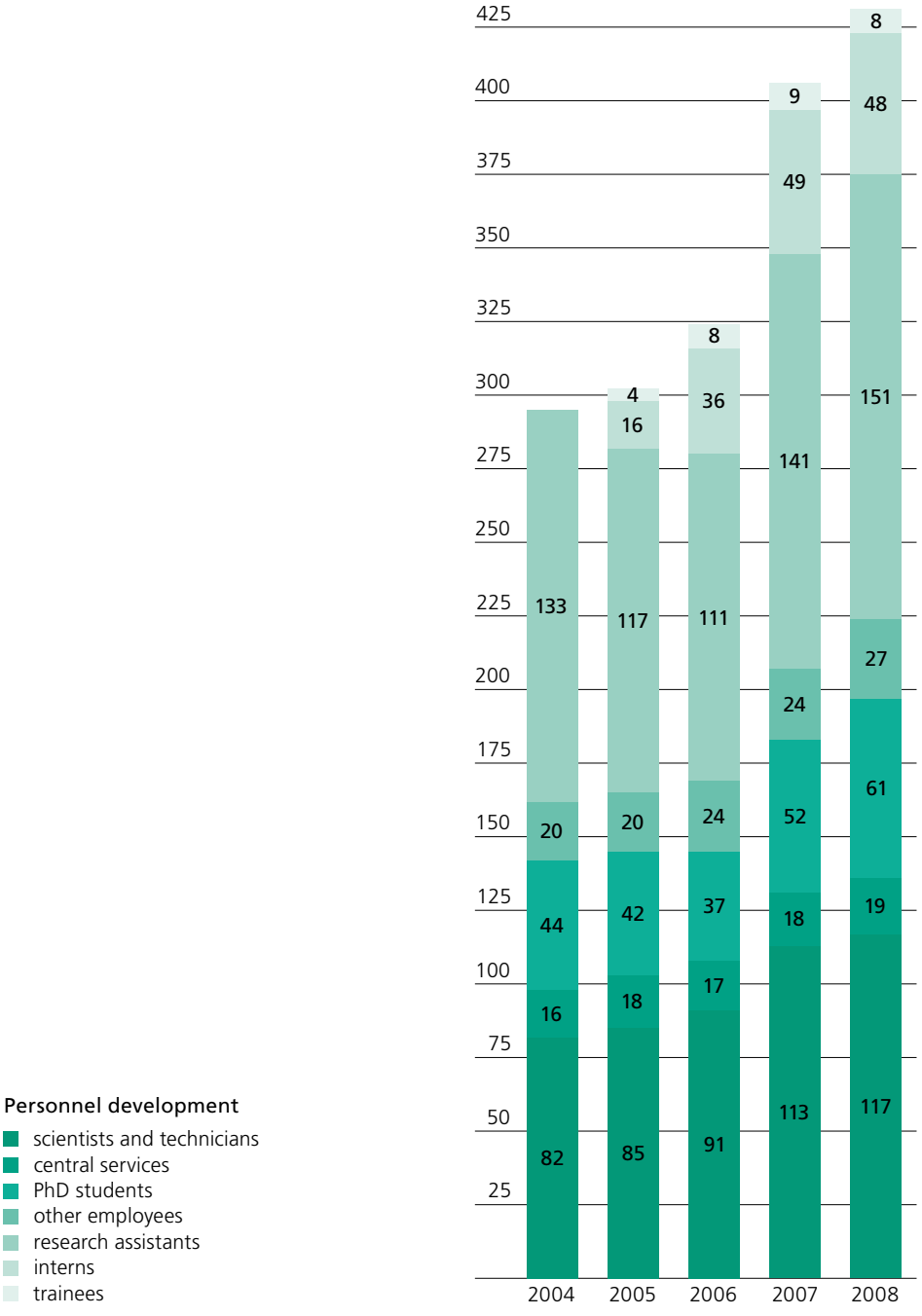


Personnel Development

Also in 2008, we successfully increased the number of employees at the ITWM by hiring 22 new colleagues. The growth rate was especially high concerning PhD students; it amounted to 17 per cent and is of course evidence of the strong attractiveness of the ITWM and its extraordinary scientific excellence.

Additional strategic alliances with the Department of Mathematics of the Technical University of Kaiserslautern, which have been initiated in 2008, are supposed to further intensify the support of young scientists. One of these is the "Felix-Klein-Center for Mathematics", founded by the Department of Mathematics and the ITWM. By the institutional connection between the teaching and research at the Department of Mathematics, which has been acknowledged and awarded frequently, and the exposed practical orientation of the Fraunhofer ITWM, a mathematical center is being created in Kaiserslautern which is exquisitely prepared for interdisciplinary research and the transfer of mathematics to economy and society. The center will further strengthen the position of mathematics at the location of Kaiserslautern, which will thus be able to sustainably preserve its currently outstanding quality concerning research, teaching, and technology transfer, in order to remain competitive on a national and international level. Excellent students will particularly be attracted to Kaiserslautern by the possibility of being awarded a socalled "Felix-Klein-Scholarship".

The support of young scientists will also play an important part at the "Felix-Klein-Center" by the initiation and establishment of activities in cooperation with schools.



The Fraunhofer-Gesellschaft at a Glance

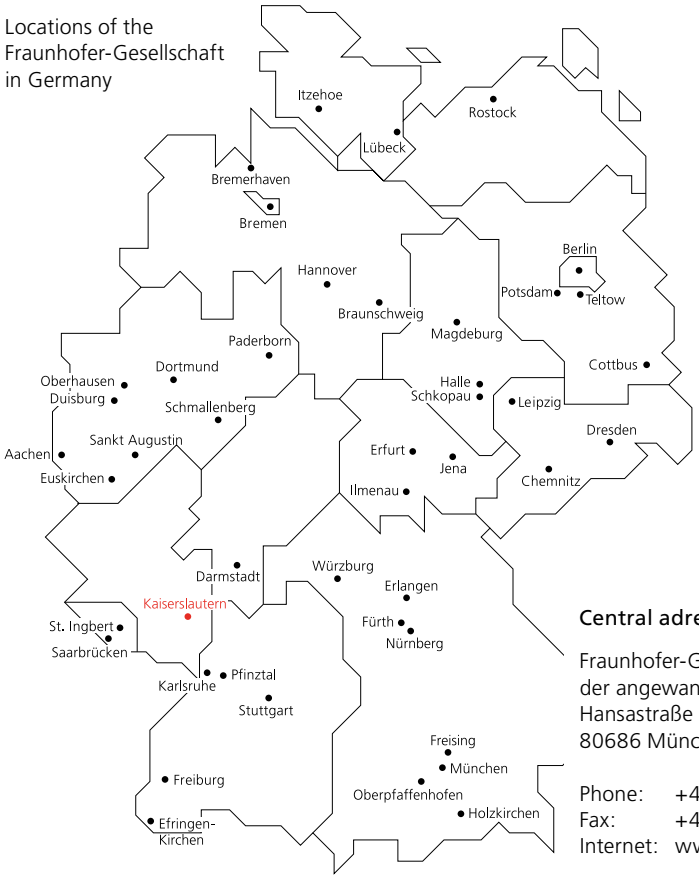
The Fraunhofer-Gesellschaft is the largest organization of applied research in Europe. As a non-profit organization, it currently maintains approximately 80 research units – including 57 institutes – at more than 40 locations throughout Germany. A staff of approximately 15,000 employees – mainly qualified scientists or engineers – works for the annual research budget of 1,34 billion Euros. More than half of industrial profits stem from projects with small and medium-sized enterprises.

The Fraunhofer-Gesellschaft deals with research and development projects ordered by economy, the state, and the public sector. International cooperation is supported by Liaison Offices in the USA and in Asia.

Research areas of the Fraunhofer-Gesellschaft:

- material technology, component behavior
- production technology, manufacturing technology
- information and communication technology
- microelectronics, microsystem technology
- test engineering, sensor systems
- process engineering
- energy technology and constructional engineering, environmental and health research
- technical-economic studies, information transfer

Locations of the Fraunhofer-Gesellschaft in Germany



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Fraunhofer Group Information and Communication Technology

Shorter innovation cycles have turned IT knowledge into a perishable commodity. The Fraunhofer Information and Communication Technology Group (ICT) provides support in the form of customized studies, technology consulting and contract research for new products and services. In addition to feasibility studies, it also investigates end-user acceptance and produces market analyses and cost-benefit assessments. The Fraunhofer ICT Group comprises fourteen institutes as full members and three associated members, representing a workforce of roughly 2800 employees. Its central office in Berlin serves as a one-stop shop, referring customers to the appropriate contacts. Research results are jointly communicated and marketed by the ICT Group, focusing on specific application areas, industries, etc.

The complementary focal fields of the participating institutes cover the entire value chain of the ICT industry. The ICT Group conducts activities within a wide range of business fields, including information and communication technologies for:

- medicine and life sciences
- traffic and mobility
- culture and entertainment
- e-business
- e-government
- production
- digital media
- software
- security
- communication systems
- financial services

Katharina Parusel, Martin Vogt, Deborah Korb, Prof. Dr. Axel Klar, Michaela Grimberg-Mang, Dieter Eubell, Michael Mannweiler, Prof. Dr. Helmut Neunzert, Prof. Dr. Ralf Korn, Gabriele Gramsch, Brigitte Williard, Prof. Dr. Stefan Nickel, Mirko Spell, Prof. Dr. Dieter Prätzel-Wolters, Gesa Ermel, Sandra Leugner, Ilka Blauth, Steffen Grützner, Dr. Marion Schulz-Reese

Transport Processes

The work of the department **Transport Processes** is characterized by the mathematical modeling of complex technical-scientific problems and the development of efficient algorithms for their numerical solution. From a mathematical point of view, the respective problems from areas such as fluid dynamics, radiative transfer, acoustics, and structural mechanics are based on partial differential equations. From the clients' point of view, problems comprise the optimization of products, the technical design of production processes, or simulation-based measurement methods. During the past year, which was an economically very successful one again, the main subjects of the department have been restructured:

Flexible structures

This main subject of the department deals with the software tool FIDYST (Fiber Dynamics Simulation Tool), thus being especially attractive for clients producing technical textiles or engineering the respective machines. Machines can be designed and improved systematically based on the simulation of the filament dynamics, for example during production processes of nonwovens.

Flow

Within this main subject, we offer the development of optimal fluid-dynamical solutions of our customers' problems; a large part of these currently come from the area of mechanical engineering. We work on technical improvements on the basis of fluid-dynamical computations (for example applying software tools such as FLUENT), as well as on optimal mathematical solutions, usually for appropriately simplified models. An example for the aspect last mentioned is the optimized control of the melt flow in spinning processes.

Grid-free methods

With FPM (Finite Pointset Method), the department has developed its own solver for a wide range of continuum mechanical problems, particularly focused on the area of fluid dynamics. FPM is a grid-free method and as such perfectly adapted for the solution of problems with a flow area changing in time (multiphase flows, free surfaces). The software is meanwhile being sold by the company NOGRID GmbH. In the past year, the application area of FPM has been expanded considerably by the integration of turbulence models.

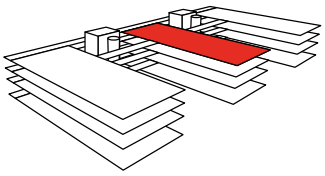
Heat, diffusion, radiation

This main subject has its roots in projects with respect to the cooling of glass by thermal radiation and heat conduction. These have always been accompanied by projects in the field of parameter identification, mostly in the surroundings of glass industry, which have essentially contributed to the development of mathematical competences in inverse problems. Current examples from other application areas and industries are the thermo technical design of SiPs (in cooperation with the department **Optimization**) and the research work with respect to pharmacokinetics in the inner ear.

Model reduction

The central objective of our research work is the development of a MATLAB® toolbox for the model reduction of large multiphysics FE systems. Besides, the group is also working on the further development of an audio-visual VR system, by which the acoustic situation of rooms (buildings, machine halls, and vehicles) can already be experienced during the planning phase.

The department's distinct ability to transfer already available methods to new application areas will be demonstrated by the following example referring to the computation of freeform lenses.



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Main subjects

- flexible structures
- flow
- grid-free methods
- heat, diffusion, radiation
- model reduction

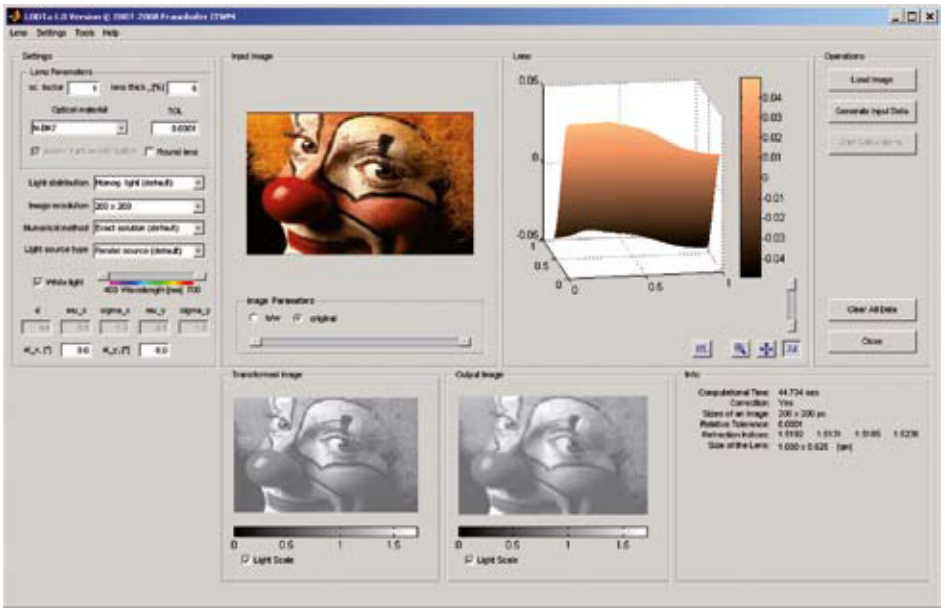
"Imaginary – with the Eyes of Mathematics" was the title of an interactive exhibition which attracted primarily young visitors to the ITWM during March and April; interactive installations and animations in the main staircase, the seminar rooms, and the patio presented mathematics as an artistic tool. Mathematics was made visually attractive especially by the user-friendly program "Surfer", by which also the lemon was created as the symbol of the exhibition.

Computation of freeform lenses

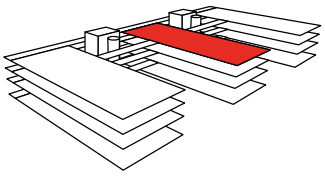
During the previous year, a very fast and extremely robust algorithm for the design of freeform lenses has been developed at the Fraunhofer Institute for Industrial Mathematics. Freeform lenses can be used for the lighting of particular areas according to fixed conditions – for example in order to display logos, symbols, and graphics. No further elements for the projection and blinding are necessary, the lens itself shaping the image; freeform lenses thus grant the optimal exploitation of light with a minimum of optics. Simultaneously, they are also perfectly energy efficient. But how does the surface of such a lens have to be shaped in order to bundle the light in the form of a specific desired pattern? The algorithm of the ITWM provides the result within a few seconds.

Classical geometric optics allows for the simple computation of the image produced by a source of light falling through any lens; of course, this also holds for freeform lenses. The inverse problem, i. e. the computation of the lens shape for the realization of a given image, is a much more complex problem which could only be solved up to now in a very time-consuming manner. The Fraunhofer ITWM has developed an efficient algorithm for the solution of this problem and implemented it into a respective software tool. On the basis of a given light distribution, the algorithm computes the shape of the lens surface within only a few seconds. A forward simulation subsequently computes the light distribution, i. e. the image realized by the lens. There are manifold application areas for freeform lenses. We immediately think of optical technologies, lighting technology, automobile industry, architecture, advertisement, logos, and graphics. However, freeform lenses can also be applied profitably in medical technology and acoustics. Everywhere where ray optics is involved, freeform lenses can make an important contribution. No matter whether you want to construct a freeform lens or a freeform reflector – the algorithm is working fast and exactly in both cases.

Currently, the software determines the surface of the lens at the opposite side of the light source. However, the integration of the side turned towards the light source is no principal problem and will be realized by a next version of the

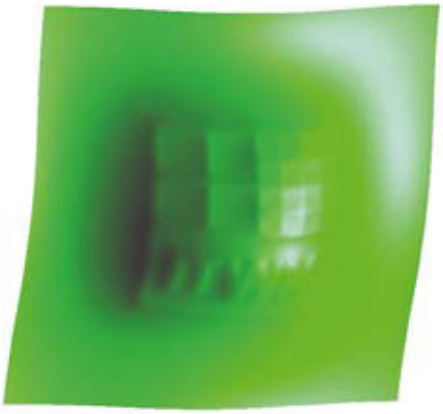


User interface of the ITWM design tool: the desired image (input image: MATLAB clown) is transformed first to a gray scale image (transformed image). Subsequently, the lens and the output image produced by the lens are computed.



software. Point sources and parallel light, which may depend on the wavelength and have different brightness distributions, are also accounted for. Besides, the tool includes a data base with different, temperature-dependent material parameters for the lens. The user can freely select the lens size and the distances between the source of light, the lens, and the screen. In order to be able to realize practical requirements as to the producibility of a lens, the software helps to examine the robustness of a lens, which has first been computed exactly, with respect to very different production tolerances and defects. The fastness of the algorithm and the user-friendliness of the software interface offer the user possibilities which are currently not available on the market.

The desired light distribution is simply entered by a *.bmp, *.tif, or *.jpg file. The computed surface of the freeform lens can be saved in IGES, DXF, or STL format, thus being readable also for other software packages. In cooperation with the Fraunhofer Institute for Production Technology in Aachen, we have been able to produce the first real lens made of acrylic glass (PMMA). This lens maps the face of a clown – image made available by courtesy of MATLAB - onto the screen. The computation of the lens surface with 400 x 400 pixels takes barely one minute with the ITWM software.



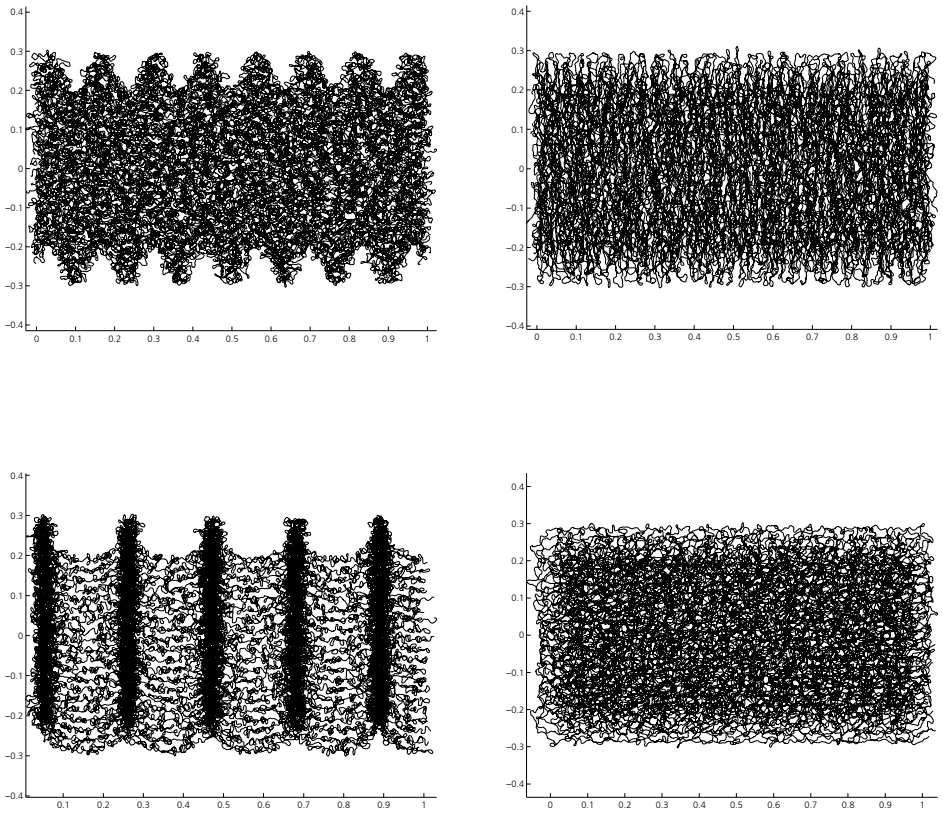
The ITWM logo

Real lens with the face of a clown

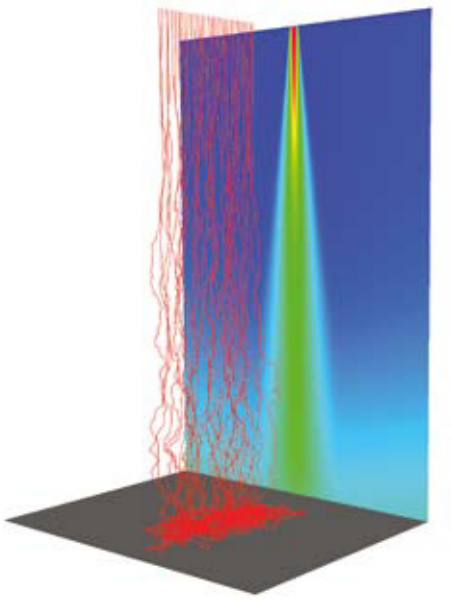
Stochastic structures of nonwovens

During the past years, the ITWM has developed the simulation tool FIDYST (Fiber Dynamics Simulation Tool). FIDYST allows for the computation of the filament dynamics in turbulent air flows, simultaneously accounting for aspects such as filament-wall interaction and the deposition of the filaments on a moving belt. The turbulence effects are accounted for by a stochastic force model based on the turbulence model of the flow computation to be carried out first. All this allows for the simulation and evaluation of different production processes of nonwovens, for example. However, the simulation of such processes with hundreds or thousands of filaments cannot be handled efficiently any longer in an easy way; it is therefore useful to make advantage of the fact that the individual filaments are subject to equal process conditions characterized by turbulent stochastic forces. On this background, the ITWM has developed a whole family of equivalent stochastic models describing the deposition of an individual filament on the belt by a stochastic differential equation. The basic idea always is the formulation of the stochastic part of the deposition process in relation to a deterministic curve, by which the belt movement or also an overlapping oscillation or rotation can be represented. The model parameters can be identified by an individual simulation done with FIDYST. The complete nonwoven can then be virtually generated very efficiently by the overlapping of many realizations of the equivalent model on the basis of the identified parameters.

In such a way, the equivalent stochastic models allow for the detailed examination of diverse influence factors on the quality of the final product, as well as for the evaluation of different deposition principles with respect to the resulting properties of the nonwoven and the respective process windows. As an example, the figures show a rotatory deposition and an oscillation in the deposition in cross direction for identical spinning and belt velocities.



Different deposition principles; above: oscillating, below: rotating, left: low frequency, right: high frequency

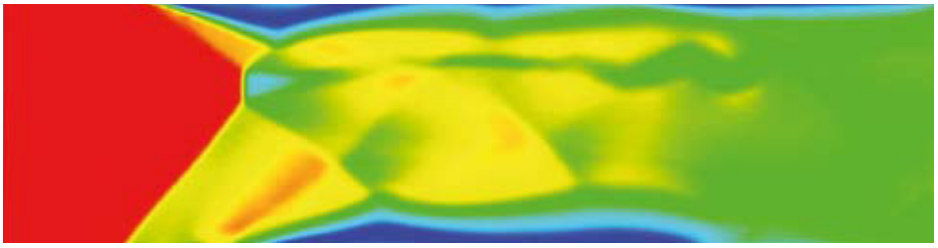


Production of nonwovens: flow and filament dynamics by FIDYST

Modeling of turbulence in FPM

The Finite Pointset Method (FPM) is a numerical simulation method which has been developed at the ITWM for ten years now. FPM allows for a very efficient solution of compressible and incompressible flow problems. The method is particularly attractive because it is grid-free, thus enabling the user to get high-quality computation results without requiring an FE grid, only on the basis of an easy to handle numerical point cloud. Especially essential is the formulation of the method in the form of a Lagrange method, i. e. the point cloud moves with the flow, thus transporting physical information in a natural way. The complete waiver of a grid reduces the effort of the user essentially to the formulation of sensible physical initial and boundary conditions. A simulation can thus be started practically during the industrial construction phase on the basis of a CAD model. FPM can be applied in a particularly efficient way to flows with free surfaces and multiphase flows, the Lagrange approach resulting in the correct description of the free surfaces' dynamics, without any additional algorithmic effort.

Mach3 step channel without turbulence model: velocity



Mach3 step channel with turbulence model: velocity

Mach3 step channel with turbulence model: turbulent kinetic energy

In industry, FPM has mainly been applied until now to the simulation of airbag deployment processes, glass molding processes, processes in chemical industry, and tank filling processes. The increasing industrial application also results in an increasing demand for a modeling of turbulence, primarily focused on airbag deployment and tank filling processes. Airbag deployment processes increasingly tend to be dominated by turbulent effects, so that computation results suffer a loss in quality without relevant turbulence models. Concerning the flow of fuels during tank filling processes, turbulence is primarily responsible for the resulting foam, which in itself is a dominating factor of the filling process.

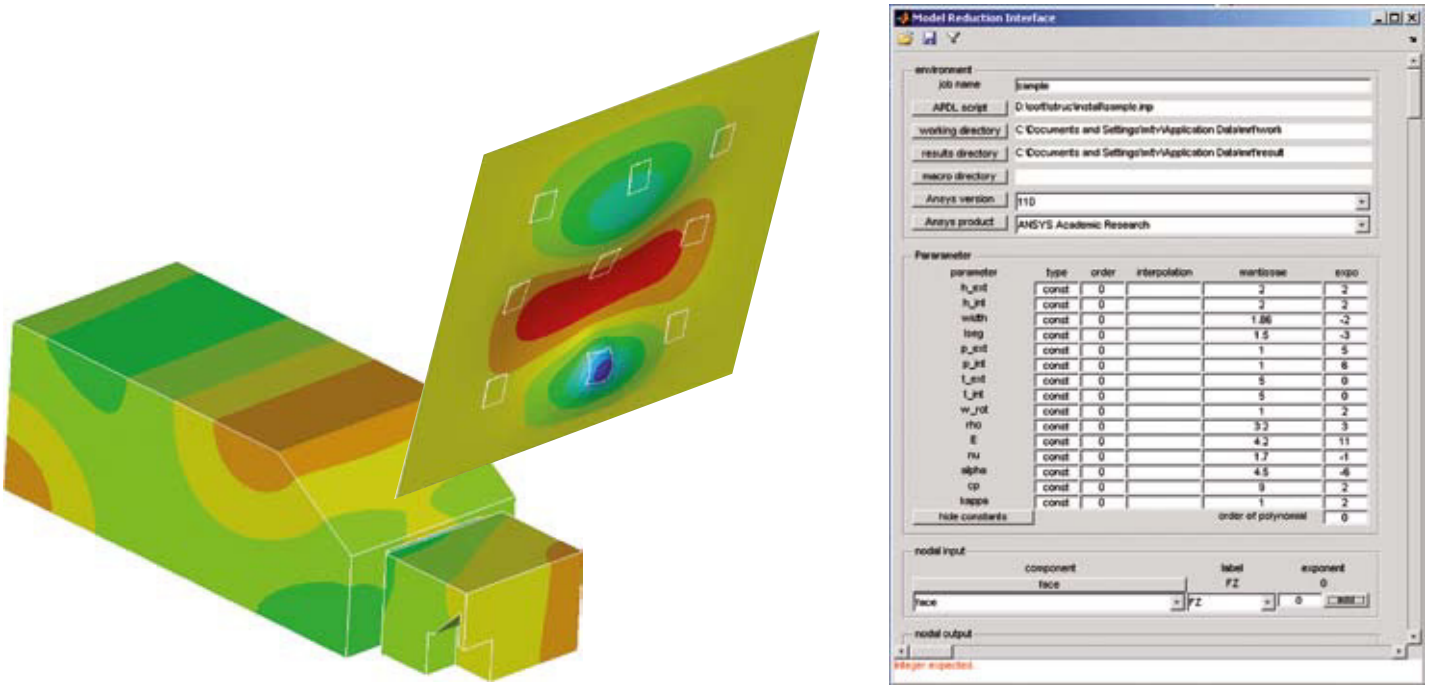
The modeling of turbulence is a specific methodic challenge for FPM. It has the character of a generalized Finite Differences Method, which is why only very few parallels can be found for the adaptation of a turbulence model in such numerical methods where turbulence has already been integrated successfully. The integration of a k-epsilon model has therefore been developed completely new. A special difficulty is the integration of turbulent boundary areas, because these mostly imply steep velocity gradient near the wall. The originally very smooth FPM approximations are limited here, so that a new FPM operator had to be developed which guarantees steep velocity gradients near the walls without any numerical "erosion" of the solution.

Toolbox for model reduction

Very different technical design problems time and again are confronted with the same dilemma: a sufficiently exact modeling results in a finite element model with so many thousands of degrees of freedom that it becomes inappropriate for typical design tasks, such as parameter optimization or controller design. Think, for example (and this is only one of many examples), of the optimal position of actor-sensor couples for active noise reduction in the interior of a vehicle. Essentially, two problems must be solved: on one hand, the original model must be reduced to one with a manageable number of state variables without falsifying the input/output behavior in the interesting frequency domain. On the other hand, the model must be transferred from the FE package to software such as MATLAB®, providing routines for controller design or optimization. The considered models often couple several fields, for example structural mechanics, acoustics, or piezoelectrics, which results in particular challenges for model reduction: singular mass and unsymmetrical stiffness matrices, non-proportional damping, the necessity of intelligent scaling, or a large number of input and output channels in the case of a hierarchical substructure. The reduction methods integrated into commercial FE packages usually fail due to the matrix structure, those of MATLAB® due to the size of the model.

In the framework of the Fraunhofer-MEF project MORAS (Model Reduction for Active Systems), we have therefore started to develop a toolbox for the reduction and transfer of FE models to MATLAB®. Further partners are the Department **System Analysis, Prognosis, and Control**, as well as the Fraunhofer Institute for Structural Durability and System Reliability in Darmstadt. Currently, there are interfaces for Ansys® and for the analysis tool PSAT for power supply systems. Outstanding features are a flexible library of problem-adapted and structure-preserving reduction methods that are also based on mode, momentum, or singular value; besides, there is the possibility of parametric reduction. The latter allows for the very efficient generation of reduced models for sets of parameters for which no FE models have been developed: previously determined reductions are interpolated. The efficiency advantage in the framework of a parameter optimization is evident.

First practical tests have been carried out successfully within the Marie Curie network Smart Structures (mechatronics), in the project NetMod (electrical power networks) – funded by the Federal Ministry for Education and Research – and within a larger industrial project which is subject to confidentiality.



Toolbox for a parametric model reduction

Dr. Dietmar Hietel, Dr. Martin Hering-Bertram, Dr. Simone Gramsch, Dr. Matthias Schäfer, Jan Marburger, Dr. Robert Feßler, Patric Keller, Dr. Marco Günther, Dr. Jevgenijs Jegorovs, Dr. Julian Stoev, Dr. Raimund Wegener, Harald Obermaier, Dr. Jan Mohring, Sergey Antonov, Dr. Norbert Siedow

Flow and Material Simulation

For many applications in product and process design, it has meanwhile become decisive to understand and account for the local structure-property relationship of fluids and materials. The department **Flow and Material Simulation** deals with the multiscale modeling and development of efficient and robust simulation methods and software tools for a virtual material design integrated into the product development process. Our software GeoDict combines manifold possibilities for a realistic structure modeling of textiles, porous materials, and composites. Representative 3d structure models of textures and multiphase materials can thus be developed on the basis of two-dimensional micro-graphs, for example; the thermo-mechanic structure properties can subsequently be determined by an automatic robust meshing (TopMesh) and a highly efficient FE computation (MatSol). The simulation can accelerate the material design enormously by a variation of the structure parameters of the 3d models. Current developments increasingly focus on the modeling of multifunctional and fine-scale depending structure-property relations of porous materials and composite or hybrid materials during the structure design; these relations are then accounted for during the structure design.

Typical application examples are diffusion and electrode layers which essentially determine the efficiency of fuel cells and batteries. On the basis of the characterization of the saturation-dependent transport properties (SatuDict), which has been the usual method up to now, current developments proceed to the additional consideration of electrochemical interactions in order to simulate and improve properties such as power density and cycle resistance. Like in many other applications especially determined by fluid-dynamical processes, this leads to the consideration of dynamic structure-property relations. The design of filter elements (SuFiS) and filter media (FilterDict) with respect to the filter efficiency and lifetime performance has remained an application area with a very strong demand.

The simulation of substance mixtures, granular materials, fiber or particle suspensions up to transition to solid body behavior, as they occur, for example, during injection molding, can be realized by an appropriate modeling of the highly dynamical structure interactions between the fluids and particles and by adequate numerical methods in the framework of continuum mechanics. The industrial application of simulation methods (CoRheoGrain) for the design of mixing plants or mills has thus become possible for the first time.

2008 was characterized by significant changes in personnel in the department, also due to many PhD theses which have successfully been concluded. In spite of this significant fluctuation, the total returns as well as the share of industrial returns have increased again, particularly due to the enormous demand for GeoDict licenses. On the basis of strategic individual developments during the last few years, additional customers could be acquired from industrial areas such as process engineering and material development.

The already established intensive cooperation with the Texas A&M University has been strengthened by a mutual exchange of personnel. The network and scientific exchange with the Technical University of Kaiserslautern have been intensified by several projects in cooperation with the department of Mechanical and Process Engineering, in addition to those together with the department of Mathematics. We have been a partner during the initiation of the foundation of the International Society of Porous Media (Interpore); in

the middle of March 2009, its first conference on "Challenges on Porous Media" took place at the Fraunhofer-Center in Kaiserslautern.

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Main Subjects

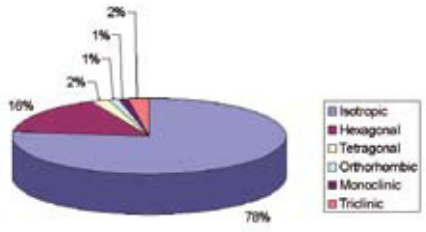
- microstructure simulation and virtual material design
- hydrodynamics
- complex fluids
- mechanics of materials

Our wall calendar 2008 visualized the bandwidth of mathematical applications to our customers and partners during the entire year. Mathematics does not only make rich and slim, it also saves time and lives and even cleans up – by materials optimized at the ITWM.

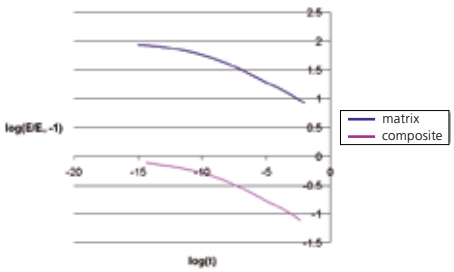
Structure-property simulation of fiber-reinforced polymers

Fiber-reinforced polymers (FK) are a preferred material in lightweight construction, because they have excellent material properties with respect to material strength and stiffness in relation to the weight of the material. The exact knowledge about the fiber orientation is decisive for the resulting mechanical properties. Already now, simulation tools are applied for a respective previous evaluation. The best-engineered tools allow for a 3d computation of the fiber orientation. However, the achievable exactness of the simulations for a robust prediction of material strength and deformation is limited already for current components. As the requirements with respect to the components increase, the quality of the simulation results must increase as well.

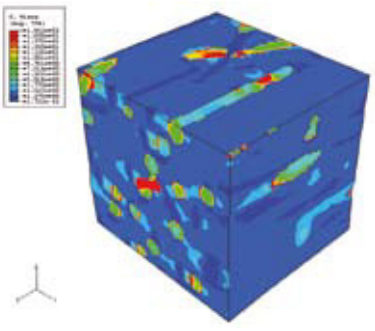
Due to the scale-dependent complexity of fiber-reinforced materials, the applied simulation methods are based on purely phenomenological models, which do not account for the basic microstructure or do so only very inexactly. Within the project MisesFok (Multiscale-integrating structure-property simulation of the fiber orientation for fiber-reinforced polymers in automobile and aircraft construction), which is funded by the BMBF, we are developing a radically different approach. Instead of improving already existing phenomenological models, the ITWM develops scale-dependent material models for fiber-reinforced polymers by methods of multiscale modeling and simulation, also accounting for the dynamical rheological material behavior during the production process; these models are prepared for application, i. e. for the prototype integration into simulation tools. The scale coupling requires modern numerical simulation methods applied on modern computer systems and is carried out on at least two levels. On the one hand, the effective rheology of the fiber suspensions as well as the resulting fiber orientations are determined explicitly by a direct simulation of interacting fibers in a polymer flow. On the other hand, the effective anisotropic elastoplastic material properties of FK can be determined by upscaling the structure mechanical computations of the fiber-matrix composite computed on the microscale. By the analysis of the solid body mechanical properties of this microstructure, we can determine exactly which isotropic and crystal symmetric proportions must be present in an effective macroscopic model in order to represent the averaged viscoelastic properties of the macroscopic component correctly. Finally, this results in a consistent multiscale simulation method for FK, from the simulation of injection molding to the computation of the mechanical properties of the molded component. Within the project, the resulting material models are tested with respect to very different application examples in cooperation with our project partners; these examples are very important from an economic point of view: glass fiber reinforced injection molded components (GFK) in automobile technology (Bosch) and for components in the interior of cars (Faurecia), and carbon fiber reinforced polymer composites (CFK) for high-performance applications in aircraft construction (EADS).



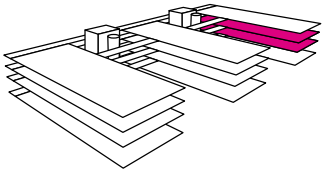
Typical distribution of a fiber composite structure; the correct model class can be deduced from the represented proportions.



The measured viscoelastic behavior of the pure polymer proportion of the composite material varies due to the proportion of fibers.



Microscopic stress distribution



Acoustic design of porous and pore elastic sound absorbers

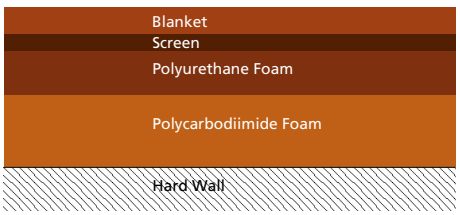
Today, primarily porous absorbers such as fiber absorbers or pore elastic foams are applied for noise insulation, i. e. for decreasing the level of acoustic pressure. Their acoustic efficiency in components or assembly groups essentially depends on their material properties and their configuration. The determination of effective material properties on the basis of models of the microstructure of the porous absorbers, which is necessary for virtual material design, cannot yet be performed by any software tool; the effective material properties must therefore still be determined by complex measurements of work pieces or prototypes. For several years now, the Fraunhofer ITWM has worked on the development of methods for a drastic reduction of time and expenses with respect to the new development of absorber materials. Instead of measuring all the material parameters determining the acoustic properties of the material, these are entirely computed.

The method is based on a stochastic model representing the microstructure of the material very realistically. Already for some time now, it has been possible to determine the purely geometric material parameters for highly porous, inelastic absorbers, in order to simulate the propagation of airborne noise in the absorber by the models of Delany & Bazley or Allard & Johnson. Now, within the MEF project (individual research project focused on SMEs) "Characterization of acoustically effective pore elastic absorbers", a method has been developed and realized as the AcoustoDict module within our software GeoDict which computes the effective (visco) elastic behavior of the porous absorber by additionally using the (visco)elastic properties of the material components, for example polyurethane. Thus, the computation of the coupled airborne and structure-borne noise can now be carried out easily by the model of Biot, for arbitrary absorber materials in the entire audible frequency domain from 100 Hz to 10,000 Hz.

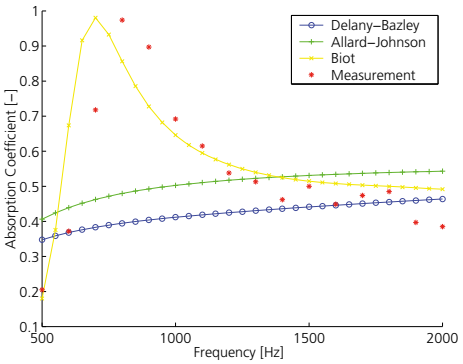
In practical applications, for example concerning the interior lining of cars, several porous materials are usuallylaid one on top of another. The software AdOpt represents a tool for the designer which can help him/her to design and optimize the material layers; additionally, it provides a data base for the effective material parameters computed by AcoustoDict.

For reasons of validation, we have realized the interior roof lining of an Audi A6 by using the effective material parameters and the thickness of the individual layers in AdOpt; the acoustic behavior has been computed on the basis of the different acoustic models. A comparison with the measurement values shows that it is compulsory for low frequencies to account for the structure-borne noise. The advantage of our method compared to all the other methods which have been available until now in the area of pore elastic absorbers is that the production of work pieces or prototypes becomes unnecessary.

Interior roof lining in the Audi A6



and its schematic structure shown on the computer



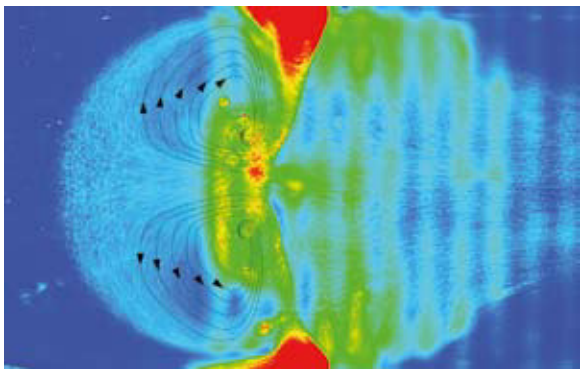
Measured (red) and computed (blue, green, yellow) acoustic absorption; the models of Delany & Bazley and Allard & Johnson fail in the low frequency domain.

Simulation-based design of virus traps

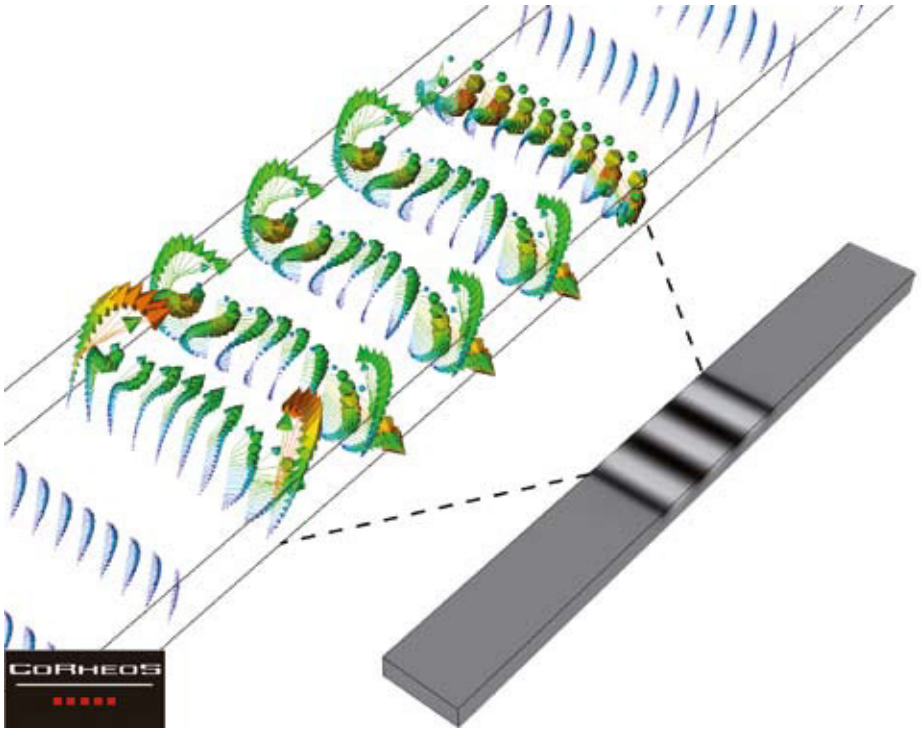
The possibility of a controlled manipulation of cells and viruses is an indispensable requirement for biotechnology industry. Many biotechnological applications either require very pure samples or a sufficiently high concentration of biological micro- and nanoparticles. However, adequate and efficient separation methods for the small amounts occurring in lab-on-a-chip technology have currently not been available at a sufficient degree. Their development is complicated due to the complex nonlinear overlapping of electro rheological effects in microchips, resulting in different instabilities. A common research project of the Fraunhofer IBMT and the Fraunhofer ITWM will enable scientists to check the desired parameters for concrete biochip design virtually on the computer with respect to instabilities or further undesired side effects. The results are intended to represent the basis of improved designs.

The project will prove by the example of the development of a cell and virus trap that the possibilities of lab-on-a-chip technology may be extended considerably by the use of simulations. The traveling wave technology developed at the Fraunhofer IBMT allows for a high-precision control of the dynamics of cells and viruses in micro-structured chips by the induction of fluid flows with the help of high-frequency fields. Particles, cells, or viruses in the fluid are transported therein and can thus be moved almost arbitrarily within a plane. However, complex three-dimensional vortex structures have been observed for certain electrode configurations, which may potentially be applied for particle enrichment methods. Unfortunately, up to now the reasons for their occurance have not been understood, fact which has prohibited their specific use.

First, the necessary electro hydrodynamic model was developed systematically as a basis for simulation, allowing for the detection of the physical mechanism of the vortex formation observed. In order to use this mechanism also in real geometries, the three-dimensional realistic electrohydrodynamic model was applied numerically. The implementation and visualization of the occurring phenomena is based on the software platform CoRheoS, which has been developed at the ITWM. If the electrode configuration applied at the Fraunhofer IBMT is used for the CoRheoS simulation, the vortex structure observed during experiments can be reproduced exactly on the computer. This is the decisive step towards a further development of the currently used lab-on-a-chip architectures into highly selective micro-traps for viruses and cells, based on simulation.



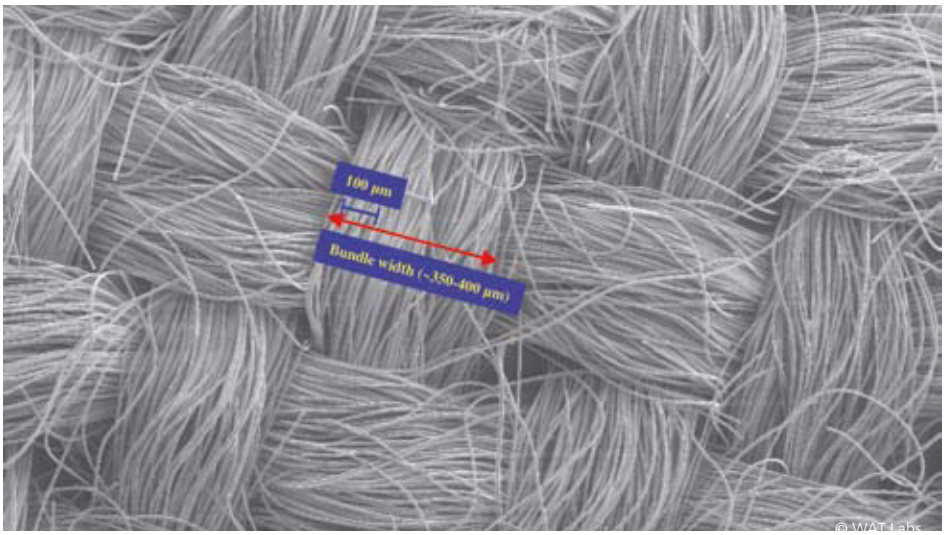
Pseudocolor image of a virus trap experiment at the IBMT, view of the channel from above; we can see the vortex structures and the resulting accumulation of particles.



Flow fields of the simulation in CoRheoS; we can see three-dimensional vortex structures which become visible only through simulation. Below on the right, the electric potential distribution at the experiment channel can be observed.

Microstructure simulation of woven fabric

The geometric properties of textiles can principally be regulated very precisely during weaving process. However, these properties are modified partially during the production process. Apart from the geometric properties, many other properties of woven fabrics are also of interest. Within current projects, these are perfusion and filtration properties; imaginable and desirable for the future are also mechanical properties.

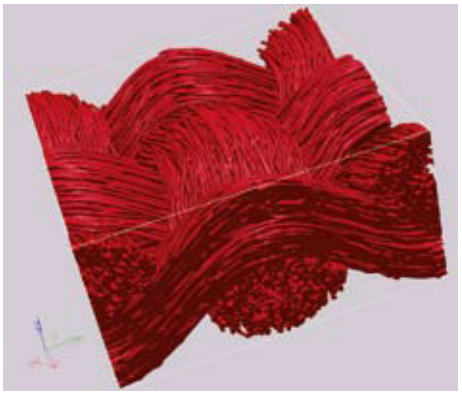


REM image of a gas diffusion medium weaved of carbon fibers

Very interesting are the properties of woven fabrics made of so-called multifilament yarns. These structures are described as a combination of regularly woven yarns and running filaments randomly positioned therein. They are, for example, applied as a gas diffusion layer in PEM fuel cells, in order to regulate the transport of oxygen towards the cathode and the transport of the resulting water away from there. Besides, they are also applied as filters for bacteria in medical protective clothing. There are research projects running for several years for both applications, as well as several smaller projects in cooperation with enterprises (fuel cells) and university working groups (protective clothing).

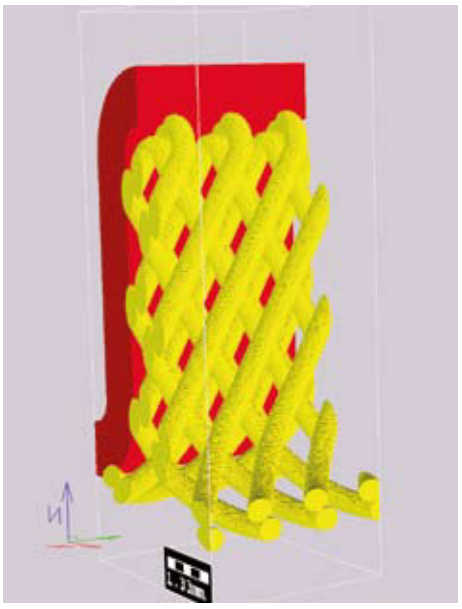
In felts especially used for the dehydration of paper, supporting fabric is applied together with nonwovens in the upper and lower layers. We simulate the drying of a width of paper during production by pressing the water into the felt. In order to be able to design felts on the computer, the woven fabric must also be simulated. The largest challenges for the simulation are partially saturated flows during the compression of the felt.

In a similar way, woven fabric is applied in hydraulic filters: it keeps the inflow and outflow channels open. In contrast to other applications, the fabric is not spread out flatly here, but shaped into three-dimensional structures instead. The computation scale is also a different one. The entire fold must be computed, so that individual fibers in the filter medium are not resolved. The pressure drop of the filter resulting from the shape of the fold, the supporting fabric, and the filter medium, is simulated and improved by parameter variations.


Model of the diffusion medium

In the year 2008, we also dealt with the simulation of wire mesh filters. Already available models for woven fabrics provide a good basis for this application. Pore size simulation, flow simulation, and load simulation of filters can be performed; in this sector, costs can be reduced by dispensing with a part of the prototypes.

All these applications can be simulated by the GeoDict software. Thus, all the computations can also be carried out at our partners' locations.


Filter pleat with supporting wire mesh (yellow)

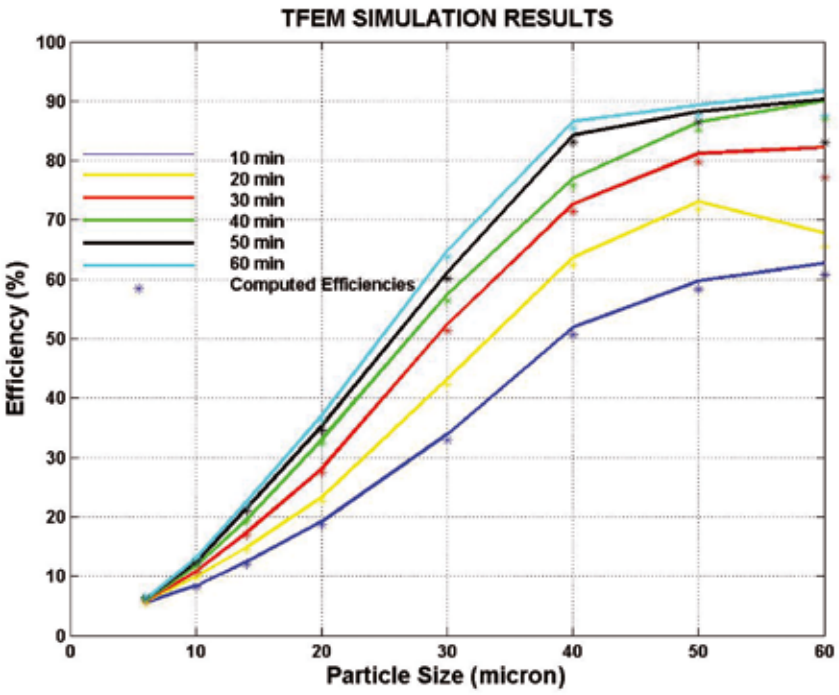
Advanced CFD simulation of filtration processes

In 2008, Fraunhofer ITWM further extended the software tool SuFiS®, which was an exclusive development for SPX Corporation. The new features for advanced Computational Fluid Dynamics (CFD) simulation of filtration processes include the subgrid resolution approach, and computer simulation of filtration efficiency tests.

The subgrid resolution is a challenging approach, which belongs to the class of variational multiscale methods. The method essentially employs a coarse grid and an underlying fine grid. More precisely, auxiliary problems are solved on appropriately selected grid cells and coefficients of the Navier-Stokes-Brinkmann equation are modified to effectively account for details of filtration medium or the filter element geometry which the computational coarse grid is unable to resolve. Special care is taken to upscale the coefficients for the Navier-Stokes-Brinkman equations so that the pressure drop of the unresolved fine scale geometrical details is approximated accurately enough.

A protoype of a complicated filter geometry. The combi filter consists of multiple porous media, separated by a metallic mesh. Very high resolution is required to resolve such geometrical details.

Another challenge in studying filtration processes is the CFD simulation of filtration efficiency tests, such as the Transmission Filter Effictiveness Method (TFEM) and multipass tests. Parameter identification from measurements carried out on a simplified filter, is combined with CFD simulation, in order to computationally predict filter efficiency for newly designed filter elements. The parameter identification is based on solving auxiliary problems for one dimensional filtration process. The developed software tool is not only used to evaluate the efficiency of the manufactured filters, but also tremendously assists the engineers in designing new filter elements and selecting the proper filtering medium. It is common knowledge that combining filtering media with different permeabilities may lead to an improvement of the performance of a filter element. However, the design of such elements is still a real challenge. Our methodology and approach illustrates how CFD simulations can efficiently assist such designs.



The figure illustrates efficiency curves for different particles sizes, ranging from 6-60 micron diameter size. The six different colors shows the efficiency curves for different time intervals.

Dr. Liping Cheng, Prof. Dr. Oleg Iliev, Dr. Aivars Zemitis, Galina Printsypar, Dr. Konrad Steiner, Dr. Andreas Wiegmann, Dr. Jürgen Becker, Priv.-Doz. Dr. Arnulf Latz, Silke Menzel, Kilian Schmidt, Sebastian Schmidt, Dr. Erik Glatt, Iuliana Matei, Tobias Zangmeister, Dr. Uldis Strautins, Priv.-Doz. Dr. Heiko Andrä, Dr. Darius Niedziela, Dr. Matthias Kabel, Raul Borsche

Image Processing

In close cooperation with partners from industry and research institutions, the department Image Processing develops especially tailored solutions in the field of image and signal processing, particularly in microstructure analysis, surface inspection, signal analysis for railway systems, and ultrasonic imaging.

Our special feature in comparison to other companies is the focus on mathematical methods and their application in the form of efficient and complex algorithms and software.

The subject of **Microstructure Analysis** has become increasingly important on the grounds of improved technical possibilities of three-dimensional imaging. At the Fraunhofer ITWM, developments are concentrating on the determination of geometric characteristics of material microstructures; however, there is also interest in applications in other areas. The software package **MAVI** (Modular Algorithms for Volume Images), which has been developed at the Fraunhofer ITWM, is systematically expanded by new functionalities for this purpose.

At the beginning of 2008, a CT scanner was acquired for the institute. Examination and analysis possibilities in the field of high-resolution tomography (resolution up to approximately 1 µm) have thus improved considerably at the location of Kaiserslautern.

The area of **Surface Inspection** profits from an increasing demand for a one-hundred per cent quality control. In many cases, there is a direct relationship between the quality of a product and the quality of its surface. The customer expects a flawless optic; scratches on automobile doors, stains on paper, or color defects in wood surfaces are undesirable. Besides, properties of the material surface frequently also have a direct influence on the functionality of the product. Cast parts with cracks are immediately discarded, for example, and defect rubber coatings of sealing gaskets reduce the sealing behavior. **MASC** (Modular Algorithms for Surface Control) is a modular system providing a large number of tools and system components ready for application. It is thus offering an adequate basis for fast and flexible solutions to meet the wide range of requirements and materials.

In the field of S**ignal Analysis for Railway Systems**, the Fraunhofer ITWM has developed the software for the chassis monitoring sleeper (FÜS), which is already running in more than 600 systems throughout Europe, in the framework of a long-standing and successful cooperation with the company GE Transportation Systems. The software analyzes radiation profiles, detects overheated components, and transfers the respective data to registration centers which are connected to the system. In order to avoid false alerts, the detection and filtering of undesired foreign radiation – e. g., by brake blocks or by direct or indirect solar radiation – has been implemented. Classification algorithms are increasingly used for the different analysis steps; these enable the user, for example, to distinguish between disk brakes and block brakes with an accuracy of almost one hundred per cent. Besides, FÜS systems are able to determine the type of chassis or brakes on the basis of the measurement data, to compute the distance between individual axles with an exactness of only a few millimeters, and to identify not only individual types of vehicles on the basis of these distances, but also complete formations of vehicles.

The year 2008 was characterized by the beginning of a large number of new projects and the development of new imaging technologies. In the field of terahertz imaging, several new projects

have been initiated in cooperation with the Fraunhofer Institute for Physical Measurement Techniques. The Fraunhofer IPM is developing the imaging terahertz technology, which can for example be applied as an alternative to Roentgen radiation. The department **Image Processing** develops algorithms and software for the evaluation of the terahertz image data.

The new area of **Ultrasonic Imaging** will open up another imaging technology, thus showing us new possibilities in combination with classic optical technology. The complex mathematical problems arising from imaging by ultrasound (including the simulation of such systems) are fitting very well into the main competences of the department.

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Main Subjects

- microstructure analysis
- surface inspection
- signal analysis (railway)
- ultrasonic imaging

During the summer of 2008, the exhibition boat "MS Wissenschaft" toured along German rivers as a mathematical boat, anchoring in 31 cities. On board, there was also an exhibit of the ITWM: defect detection on cow skins; surface inspection as a real experience for visitors, with a game, animation, and a real cow skin.

THESEUS

In the framework of the large-scale project "Theseus", funded by the Federal Ministry of Economy and Technology, the Fraunhofer-Gesellschaft is cooperating with other research institutes and technology enterprises in the development of the so-called Semantic Web. The objective is the development of an almost cognitive understanding of the complete knowledge available on the internet. The Fraunhofer ITWM is integrated into the use case "Ordo", which deals with the automatic analysis and standardized cataloguing of internet data.

Ordo is focused on the so-called "Digital Desktop", which provides personal and structured access to digital information for professional and private users. Digital information, such as text documents, images, and videos, is not only available locally on one PC, but instead also comprises data from the internet, as well as company-specific data from an intranet.

Therefore digital information must be classified automatically and sorted into personalized displays for the respective user. The user will thus be spared from a complex manual collection and structuring of the digital information.

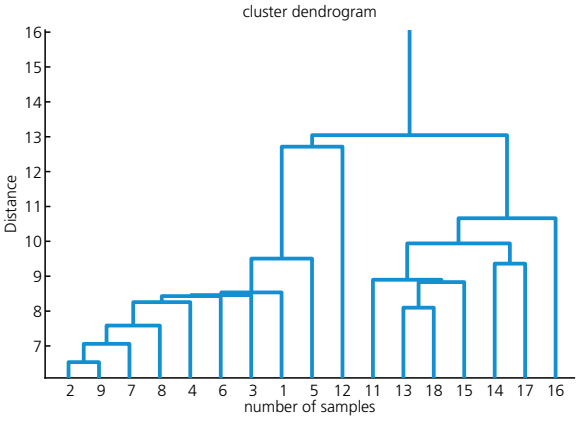
The task of the department **Image Processing** within Ordo is the development, testing, and validation of a hierarchic clustering method for large and heterogeneous stocks of documents.

Hierarchic clustering means the formation of groups of similar objects (clusters) within a hierarchy. The cluster generation is based on a similarity measure. Hierarchic clustering begins with the formation of a cluster for each individual object. These initial clusters are then combined iteratively to new clusters (comprising several objects). The final result is a tree diagram, which is called dendrogram. Depending on the method, the distance between the clusters corresponds to the smallest, largest, or average distance of the objects within the cluster. This means that the process must be adapted to the respective application and the respective similarity measure.

In the framework of Ordo, this method is for example applied for the hierarchic clustering of search results; instead of a simple list of results, the user will receive a tree showing groups of search results. Each of these groups comprises semantically similar results, enabling the user to navigate faster and easier through the search results; besides, he/she is provided with additional semantic information about the structure of the results.

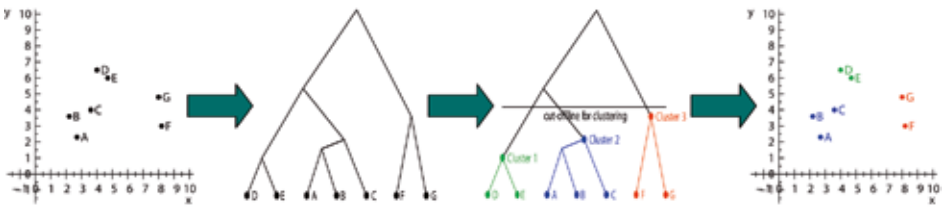
Hierarchic clustering is very slow in the classical implementation. Due to the large volumes of data during the search in stocks of data, the method is re-implemented in the form of a process based on parallel computing. A first version of the hierarchic clustering has already been implemented into the application "NewsFinder" by the company empolis.

THESEUS
Forschungsprogramm für eine neue internetbasierte Wissensinfrastruktur



Example for the presentation of the results of hierarchic clustering in the form of a dendrogram.

Example: hierarchic clustering of points in 2D

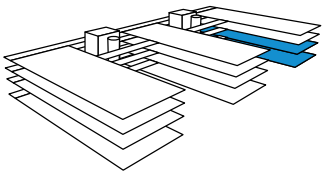


Task:
sort the points according to their distance

Step I:
form a binary tree subsequently combining the points next to each other

Step II:
set a threshold within the tree; all the subsequent branches are clusters

Result:
automatic sorting of the points into groups



Tekzas – terahertz real time camera for applications in security technology

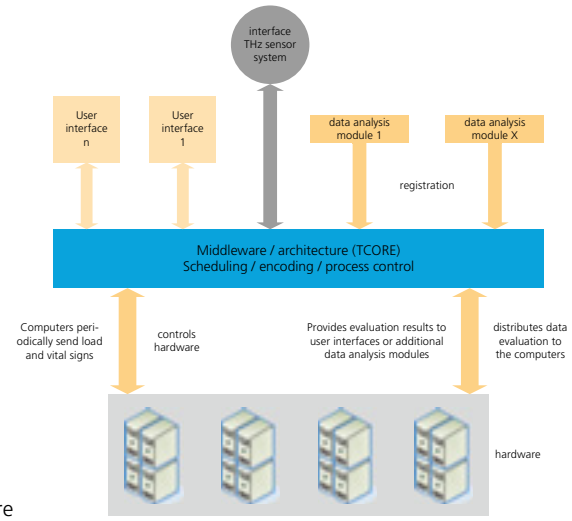
The objective of the project Tekzas, which is funded by the Federal Ministry of Education and Research, is the development of a multi-sensor system for the remote detection in real time of chemical, biological, and explosive hazardous material hidden on the body, particularly considering persons moving around an airport terminal.

The physical basis for the detection of hazardous material is the so-called terahertz radiation. In the electromagnetic spectrum, this radiation is located between infrared and microwave radiation, and allows for the detection of many explosive substances through packaging material or clothes. From a technical point of view, Tekzas realizes a multi-sensor system consisting of a passive terahertz camera, a standard optical camera, and an active terahertz sensor.

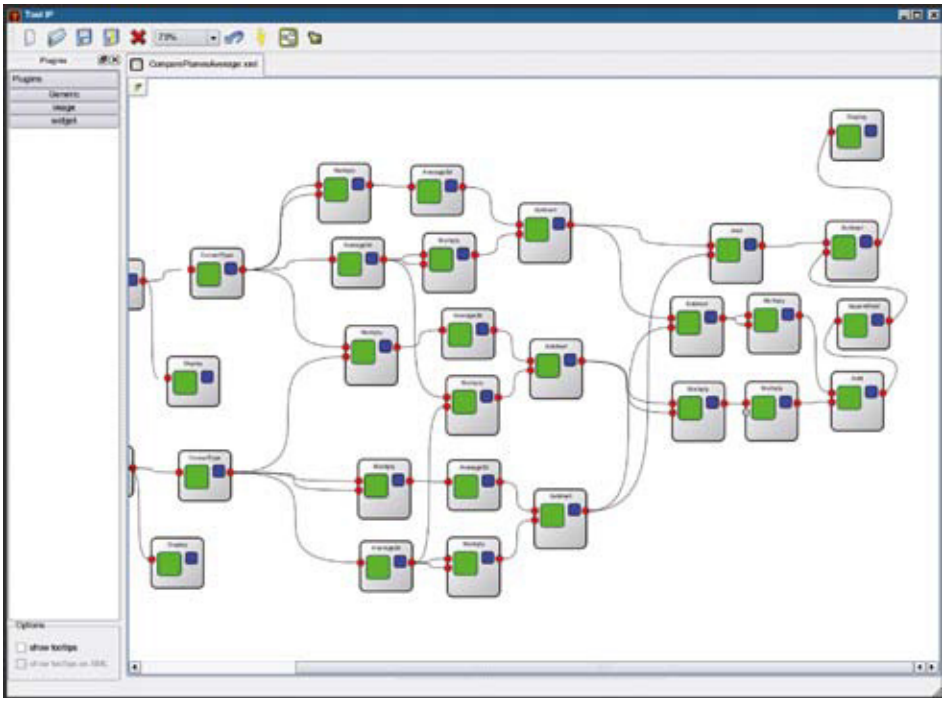
The resolution of passive THz cameras is very low (approx. 40 x 50 pixels); a first step can therefore only result in a rough detection, i. e. a list of body regions where there might be hazardous materials. The active terahertz sensor is only able to carry out an exact spectroscopy within a very small area of approximately 5 cm; a software tool will therefore focus the sensor – on the basis of the list of potentially hazardous materials and the optical camera image – in such a way that several body regions can be examined more closely. During the remote detection process, very large amounts of data are produced which must however be processed in real time, i. e. with a reaction time of less than two seconds.

The department **Image Processing** realizes the central computer architecture for the real time evaluation of the sensor data, as well as uniform communication interfaces between the components of the entire system. For reasons of data protection, the architecture encodes all the respective data, as well as the communication between all the components. The control of the multi-sensor system is very complex and the data evaluation is very time-consuming; the computer hardware therefore consists of 16 cores distributed between two computers.

It is only possible to exploit the performance of such a computer cluster completely if the data processing modules take advantage of the parallel system. On the basis of the experience in the field of industrial image processing, the department has developed parallelization methods for data evaluation during the last few years. These methods can now be used very well for the development of the Tekzas architecture.



General structure of the Tekzas software architecture



Display of a parallel data evaluation in the form of a graph

Image analysis of fiber-reinforced polymers

Fiber-reinforced polymers consist of a polymer matrix with fibers incorporated therein. The fiber materials are often glass or carbon. These fibers have a higher stiffness than the surrounding polymer, which results in a strong durability of the composite along the fibers. Due to their light weight and high specific stiffness and durability, fiber-reinforced polymers are especially good materials for lightweight construction, for example in automobile or aircraft construction.

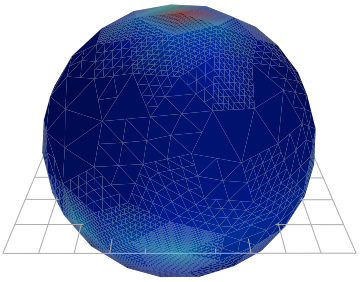
Because of the different properties of the fibers and the polymer matrix, the material properties vary depending on the structure of the fibers within a sample: parallel fibers result in a high tensile loadbearing capacity of the fiber composite in one direction, whereas fiber systems with a completely random orientation (isotropic) yield composite materials with a direction-independent mechanical load-bearing capacity. It is therefore important for the control and improvement of the production of such fiber composites to be able to determine the fiber orientation in fiber-reinforced polymers.

In close cooperation with partners from industry and research institutions, the Fraunhofer ITWM has developed algorithms for the analysis of fiber systems in fiber-reinforced polymers on the basis of 3D volume data stemming from micro tomography (µCT). We consider parameters such as the local fiber densities and orientations. These analyses are able to quantify deviations from a planned fiber struc-ture which are due to the production process, as well as the consequent mechanical properties, in order to optimize the production processes of fiber composites. A practical example is the development of an especially lightweight rim within a Fraunhofer project in cooperation with the Fraunhofer LBF in Darmstadt.

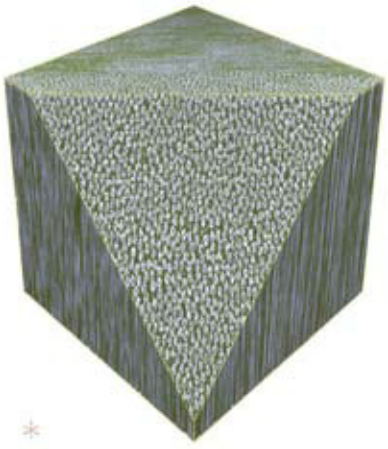
The special challenge concerning the development of algorithms for the determination of the fiber orientation results from the size of the fibers to be examined; it is close to that of structures which can barely even be rendered by modern µCT technologies. Typical carbon fibers, for example, have a diameter of less than 10 µm (0.01 mm), and it is very difficult to recognize densely packed fibers in image data even visually. The software developed at the Fraunhofer ITWM solves these problems by recognizing brightness gradients in 3d images and drawing conclusions about the position of the fibers in 3d on the basis of already available information about the diameters of the examined fibers.

These developments are providing methods for the 3d image analysis of fiber-reinforced polymers, methods which give the materials scientist valuable information for a further improvement of innovative lightweight components.

Fiber-reinforced polymers are applied as lightweight construction materials, for example for an especially lightweight rim.



Histogram of the computed local carbon fiber orientations: in this case, the evaluation shows two fiber components with different fiber orientation.



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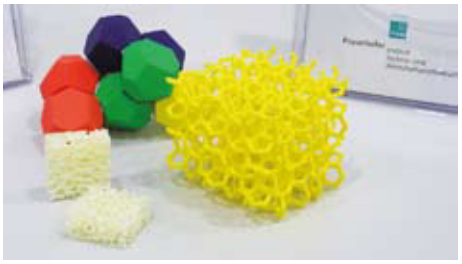
Volume visualization of a µCT image of a carbon fiber-reinforced polymer

Carnot-Fraunhofer cooperation project Virtual Material Design

For several years now, the department **Image Processing** has successfully applied methods of mathematical morphology in research and industrial projects, simultaneously further developing these methods. The cradle of mathematical morphology was at Fontainebleau, where the theory developed by Georges Matheron and Jean Serra has been further developed continuously and also used in applied research projects at the Centre de Morphologie Mathematique of the Ecole des Mines. Cooperation suggested itself; when the Ecole des Mines was classified as a Carnot institute – an organization of French research institutes similar to the Fraunhofer-Gesellschaft –, we had the chance to intensify already existing contacts in the framework of a concrete common project.

The microstructure of a material essentially determines its properties, such as durability or conductivity. Modern micro computer tomography and image processing and analysis allow for the geometrical characterization of the spatial microstructure. In order to overcome the limits of this analysis method determined by the size of samples, spatial resolution, and image quality, the microstructure is often modeled. Stochastic models are applied in order to account for the microscopic heterogeneity of the materials. The parameters of the stochastic geometry models are determined on the basis of the image data. The models adapted in such a way allow for a better understanding of the geometric structure, as well as for the generation of realizations – i. e. simulated microstructures – in almost arbitrary image sizes and numbers. The influence of the microstructure on the macroscopic material properties can then be examined systematically in these realizations by numerical simulation. The project comprises the entire chain of virtual material design, from the 3D image acquisition and segmentation, image processing and analysis, and the selection and adaptation of a stochastic geometry model, up to the simulation in different depths of foams, fiber materials, and sintered materials.

Apart from the new and further development of image processing, image analysis, model adaptation, and simulation methods, further important objectives of this project are the exchange of ideas and personnel, as well as the preparation of new common projects. The participation of PhD students of the ITWM in spring and autumn schools of the Ecole des Mines, a common PhD project, and the common workshop "3d imaging, analysis, modeling, and simulation of properties" serve this purpose. The workshop, which was held at the ITWM in autumn 2008, did not only bring together scientists from France and Germany dealing with theoretical and practical problems, but also from Spain, Finland, Sweden, and Belgium.



Workshop exhibits: the yellow grid structure stems from the 3D printer of the ITWM

The workshop was complemented by an exhibition about Virtual Material Design

Simulation of the ultrasonic defect detection on titanium billets

A decisive element for safety in aviation is the behavior of the propulsion system, particularly the safe operation of the rotating engine components. At the beginning of the 1990s, an analysis of the Federal Aviation Administration (FAA) and several companies led to the conclusion that in most cases, the engine problems were caused by a failure of the turbine blades. The raw material of these blades are cylindrical billets of high-performance alloys such as titanium-6-4, supplied in different diameters and examined with respect to possible defects according to the FAA regulations prior to any further proc-essing. In order to further improve the high safety standards, the company MTU Aero Engines GmbH, one of the leading producers of aircraft engines in Europe, uses different strategies for increasing the sensitivity of the ultrasonic methods applied for the examination of the billets. Among these strategies is also the simulation of these examinations by the ITWM on the basis of ultrasonic imaging.

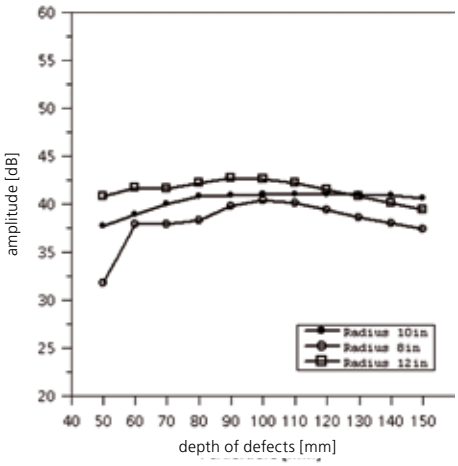
In the case of the immersion method, the billets are treated with ultrasound underwater and scanned in a defined way by ultrasonic scanner heads. If there are any defects – such as pores or oxide inclusions, which might decrease the load-bearing capacity of the material – the ultrasound waves are reflected there and detected by the sensor. The defect size can then be determined on the basis of these signals; according to the regulations, a critical defect size must not be exceeded. The sensitivity of this method primarily depends on the properties of the applied scanner head.

The objective of a study for the company MTU therefore was the optimal selection of an ultrasonic scanner head on the basis of commercially available standard sensors. The defect examination of titanium-6-4 billets with a diameter of 10 inches was simulated in order to determine specific scanner parameters on the basis of the computed sound fields and defect signals. As a model defect, we considered a drilled hole on even ground with a diameter of 0.8 mm in a depth of 130 mm.

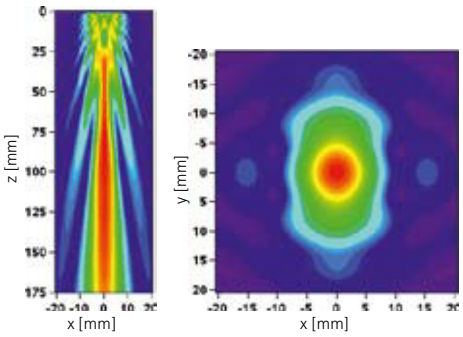
The computations were carried out on the basis of a point source overlapping method. In order to predict the time signals correctly, we have modeled the different physical processes connected to the examination problem. These are the radiation of the ultrasound waves by the scanner head and the propagation of the waves within the respective medium, the reflection and transmission process at the boundary water/titanium billet, and the scattering of the waves hitting the simulated defects.

Due to the convexly curved billet surface, an evenly shaped scanner head leads to an undesired defocusing of the sound field. This effect can be neutralized by a respective shape of the oscillating piezo element. Computer optimization provided the following result: a homogeneous sound field over a depth from 50 mm to 150 mm can be produced by a cylindrically curved oscillator with a radius of curvature of 9" focusing in the radial plane.

The simulation methods available at the ITWM in the field of ultrasonic imaging are similarly applied for the improvement of defect detection with respect to a large number of components and materials.



The maximum amplitudes – standardized to a reference specified by MTU – of the computed defect signals as a function of the depth of the 0.8 mm drilling hole, for billet diameters of 10", 8", and 12"; the cylindrically curved scanner head shows a more or less consistent maximum error amplitude over a depth from 50 mm to 150 mm, i. e. a consistent sensitivity approximately 40 dB higher than the reference amplitude.



Billet radial plane in linear scaling (left); a cross-section of the sound field in a depth of 130 mm (right), the depth of the 0.8 mm drilling hole; the (optimal) start-up length for water for defect detection is 100 mm.

Rebekka Malten, Kai Taeubner, Tetyana Sych, Prof. Dr. Martin Böhm, Michael Godehardt, Andreas Jablonski, Dr. Claudia Redenbach, Hans Rieder, Dr. Ali Moghiseh, Franz Schreiber, Thomas Redenbach, Falco Hirschenberger, Henrike Stephani, Martin Braun, Thomas Eckert, Markus Rauhut, Dr. Oliver Wirjadi, Dr. Ronald Rösch, Mark Maasland, Dr. Stephan Didas, Dr. Katja Schladitz, Björn Wagner, Priv.-Doz. Dr. habil. Martin Spies

System Analysis, Prognosis and Control

The data- and knowledge-based modeling of complex technical and biological systems and processes is a central objective of the department **System Analysis, Prognosis, and Control**. Depending on the specific problem, the resulting models either allow for the simulation and classification of the system or process behavior, the derivation of new knowledge, or the prognosis of the future development. Besides, the identified models also form the basis and main element for the development of efficient monitoring and control methods. In these surroundings, the department is offering pure consulting services and customer-specific software development, as well as individually developed products. It is currently working on the following five main subjects:

The main subject **Dynamic Heterogeneous Networks** deals with the modeling and analysis of complex system networks. Error controlled mixed symbolic/numerical model reduction methods are the key for a better understanding of the systems and an efficient simulation. There are numerous applications for these methods, from the EDA tool Analog Insydes to the simulation and analysis of electric power supply networks and complex technical measuring devices.

Activities in the area of **Monitoring and Control** concentrate on the model-based design of controllers and observers. The basic models can be derived from physical principles or determined by appropriate identification methods on the basis of measurement data. Important methods are robust control strategies, iterative learning control methods, model predictive control, and neural controllers. Current applications lie in adaptronics and the conditional monitoring of large technical systems.

It is the mission of the main subject **Decision Support in Medicine and Technology** to offer support in the case of complex diagnosis and decision-making processes. The methods applied stem from the fields of multivariate statistics, time series analysis, data mining, and fuzzy logic. The tool knowCube is currently developed for the support of interactive decisions in the case of multi-criteria scenarios. In 2008, activities also focused on the cooperation in the 2nd Presidential Project of the Fraunhofer-Gesellschaft for the acceleration of technology development processes.

In the area of **Prognosis of Material and Product Properties**, models for prediction, classification, and simulation are determined by methods of system identification. On the basis of the identified models, expanded system knowledge can be generated by appropriate sensitivity analyses; apart from experimentally determined data, simulation data bases are also increasingly used for the development of these models. The methods have for example been applied to the prediction of durability parameters of automobile components, or to the prognosis of residual errors in software components.

The main subject **Multiscale Structure Mechanics** deals with the development and application of numerical algorithms for solid body mechanical problems concerning materials which show a complex multiscale structure and are simultaneously subject to complicated time-dependent constitutive laws. Asymptotic homogenization methods can be applied for the examination of strength and durability subject to fatigue, contact problems in the case of microrough surfaces, creep, impact loading, and wear. During the period covered by this report, we have primarily dealt with the design of implants and the compu-

tation and optimization of mechanical properties of textile fabric structures.

The year 2008 was a very successful one for the department from an economic point of view. Besides, two projects substantial for the strategic subjects of the department could be acquired and initiated in cooperation with several other Fraunhofer institutes; the subjects of these are the hierarchical simulation of nanoelectronic systems and data mining in production surroundings.

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Main Subjects

- dynamic heterogeneous networks
- monitoring and control
- decision support in medicine and technology
- prognosis of material and product properties
- multiscale structure mechanics

In August and September, the exhibition "A Mathematical Art Book – an Artistic Mathematics Book" by Franz Xaver Lutz was shown at the ITWM. In his works, the artist builds a bridge between arts on one side and mathematics and biology on the other side, symbolized by the ammonite.

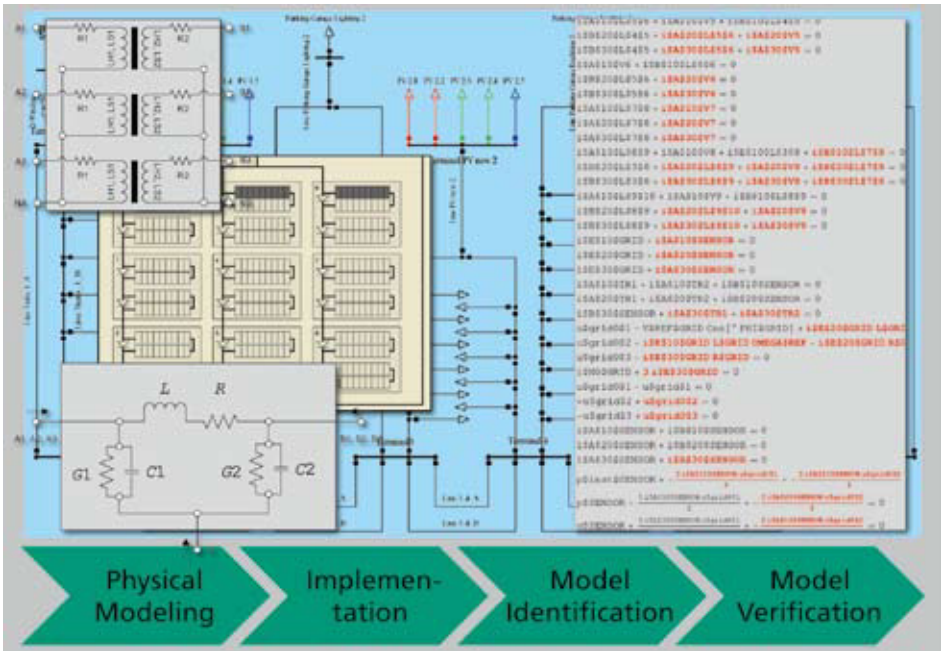
Modeling and simulation of networks with decentralized regenerative energy production

Due to the liberalization of the electricity market and the strong penetration of the market by decentralized regenerative energy production, there is a growing need for efficient automatic methods for the design and management of modern energy distribution networks. These are very important for a successful expansion of decentralized regenerative energy systems.

The management and design of such energy networks comprises numerous control and optimization problems, each requiring differently detailed models – also differing as to the resolution with respect to time – of the three hierarchic levels of low, medium, and high voltage networks. Due to the possibility of a decentralized feed-in and the separation of network management and electricity trading in a liberalized market, individual engineers often do not have any direct access any longer to all the data required for the development of their models.

Especially on the medium and low frequency levels, the network has become more and more complex by additional independent energy production plants, and keeps constantly changing. By now, numerical simulation allows for a very detailed network modeling; system dynamics and management in electrical sub-networks can already be described very well.

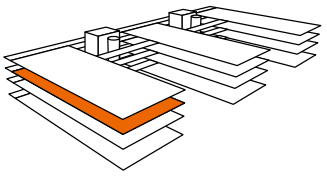
Concerning larger networks with many sub-networks, the methods are limited: in order to reduce numerical effort, model reduction methods become increasingly necessary. Only these methods will allow for the optimization of the networks, the exact design, and the superordinate management. All in all, there is a demand for automatable, flexible, and efficient methods. With-



Modeling of energy distribution networks as a process

in the research project NetMod of the Federal Ministry of Education and Research (www.netmod.org), we have succeeded in developing a new modeling approach which allows for the consistent generation of behavioral models for electrical energy networks by symbolic methods. This modeling approach, which has originally been developed for analog circuits, has successfully been transferred to this new application. Besides, symbolic model reduction methods can decisively reduce the complexity of the models, so that more advanced applications, for example the system simulation or optimization tasks, can now be handled.

The developments are based on the proprietary tool Analog Insydes. Project results are, for example, the development of a symbolic basic model library for typical system components in an electrical energy network, and the new interface for the standardized modeling language Modelica. This work represents the basis for the application of new technologies for an optimized design and management of electrical energy networks with a high percentage of decentralized producers and storage systems.



Compensation of the run-out signal of inductive torque sensors

In the context of rotating machines, the torque is one of the central parameters to be monitored. Non-contact measurement systems which can be positioned flexibly at the shaft are able to detect variations of the torsional stress at the shaft surface on the basis of the inverse magnetostrictive effect of ferromagnetic materials; they can be used as an alternative to classical torque sensors. One of the advantages of inductive magnetostrictive sensors is that their application does not require any construction modifications of the shaft; they can be applied flexibly without influencing the system dynamics. In the case of ferromagnetic materials, mechanical loads lead to a change of the magnetic permeability; the resulting permeability differences can be measured by a magnetostrictive sensor.

However, stresses at the shaft surface do not only result from external loads. The production process already yields inhomogeneities at the shaft surface in the form of frozen stresses. These depend on the location, so that a general a priori classification is impossible.

During the torque measurement at a rotating shaft with the inductive sensor of the Fraunhofer ITWM, we must therefore account for the fact that material inhomogeneities are varying along the measurement trace over the entire circumference. Due to the shaft rotation, the signals resulting from the inhomogeneities keep reoccurring in the same sequence along the measurement trace around the shaft circumference, thus yielding a deterministic and periodic interfering signal, a so-called run-out signal. If the shaft is subject to an external torque, the original torsional signal is overlapped by the interfering signal and additional measurement noise. In order to eliminate the run-out signal, classical signal filters (notch, low-pass, or high-pass filters) can be used in several applications. However, if an interfering frequency and a critical torsional frequency coincide, the torsional oscillation signals will also be eliminated by the filters; the interesting oscillation information will be lost.

The parameters of a model of the run-out effect are determined online by a constrained extended Kalman filter, or alternatively by an impulse measurement per rotation; the run-out signal is predicted accounting for the entire signal filters in the measurement chain. The resulting signal is than subtracted from the measurement signal in order to compensate the run-out. These methods developed at the ITWM within the MEF project TorSys allow for the use of the torsional sensor also in the case of those applications where there are only low torsional stresses at the accessible measurement points of the shaft.

Torque monitoring software with integrated run-out compensation: the oscilloscope shows the original measurement in red; the blue one is the filtered signal.

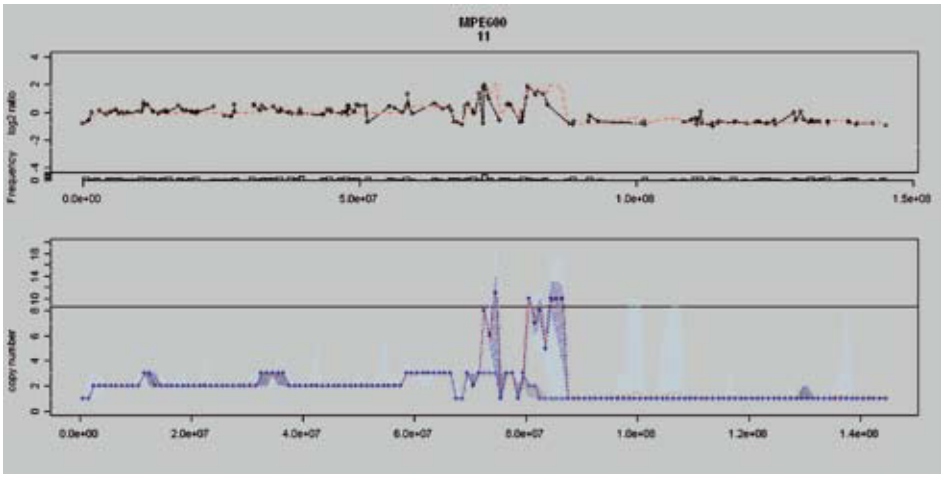
Estimation of the number of gene copies by array CGH

Deviations in the number of gene copies of chromosomal DNA occur on different scales. We know about mutations of individual DNA base pairs (single nucleotide polymorphism, SNP) on small scales and aneuploids (abnormal number of chromosomes) on large scales. The deviation of gene copies on medium scales has only been considered more recently. In diploid autosomal cells, chromosomes always occur twice, so that the normal number of copies is two. Deviations can be observed particularly in tumor cells. Numbers of zero or one indicate a loss in one or both of the chromosomes compared to normal DNA; copy numbers of three or more stand for a multiplication of chromosomal regions. We can even find multiplicities of an order of magnitude of ten or hundred (so-called amplifications).

In order to find these deviations of gene copies on medium scales, we use comparative genomic hybridization (CGH). CGH compares the DNA of a sample (e. g., of a tumor) with normal reference DNA by the hybridization of both with complementary DNA (hybridization is the bonding of two complementary individual DNA strands by hydrogen bonds). Prior to the hybridization, the reference and sample DNA are both marked by different fluorescent color molecules. After the hybridization, the ratio of the light intensities of these markers represents the ratio of copy numbers of the sample DNA and the reference DNA.

There are two different variants of CGH, depending on whether hybridization is done via metaphase chromosomes or via microarrays. Microarrays are glass slides on which short DNA sections are printed at predefined points. The advantage of array CGH is a higher resolution compared to metaphase CGH. The main problem is a large noise component during the measurements. Special technology is required in order to extract the interesting signal (the number of gene copies) from the noisy measurements.

We already have several algorithms for the solution of this problem. In cooperation with the Max-Planck Institute for Molecular Genetics in Berlin, a new algorithm was developed in the framework of the Learning and Inference Platform (LIP). The number of gene copies is modeled as a hidden random process, and the estimation is based on sequential Monte Carlo methods (SMC). The advantage is the freedom of the modeling: SMC does not require any special restrictions of the model. This allows for a simultaneous classification. We can thus distinguish between moderate gene copy devia-tions and high amplifications, additionally receiving information about the reliability of the estimations. This is much more difficult with the already existing algorithms.



Example of an estimation of the gene copy number for a chromosome; above: microarray measurements and estimations of the log2 ratios; below: estimated and classified number of gene copies

Focus Technology – Recognition of Chances, Development of Performance

How can new technologies be identified and evaluated? What is the stage of evolution of a technology? How can technologies be developed systematically? How far is a company able to do so? How can the entire technology development process be organized efficiently?

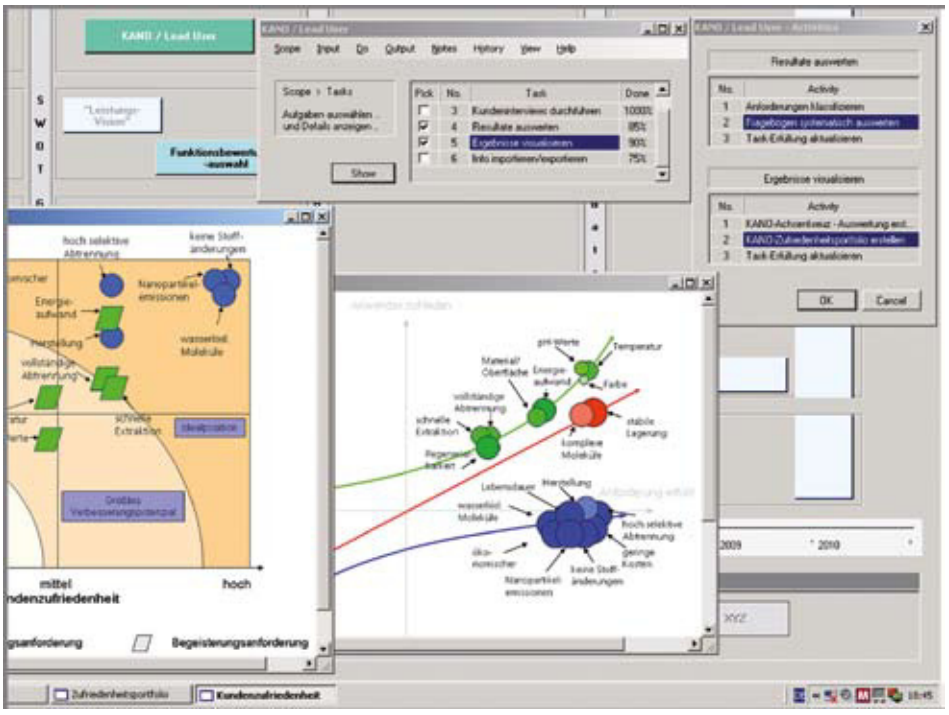
These questions were asked at the beginning of a Fraunhofer-internal project in which research groups of eight Fraunhofer institutes participated. Two years later, the project has now resulted in a series of instruments: the technology radar and audit primarily developed by the Fraunhofer IAO, for example, serve for an early recognition and selection of relevant technologies, and for the measurement and evaluation of the ability of a company to develop new technologies.

At the ITWM, we examined methods for the simultaneous comparison of the time gradients of technology indicators, and implemented these into the software "progress". The software allows for the determination of the evolutionary stage of a technology with respect to a reference. Indicators are pa-rameters such as the number of application-oriented patents or the number of specific publications. These data are provided by a data server developed at the Fraunhofer IITB.

The methods cockpit, which has also been developed at the ITWM, integrates the above mentioned instruments and provides a platform for the support of systematic technology development. The software presents methods templates to the user for a project-specific selection, indicates the respective method-specific tasks including required activities, thus leading the user through the entire process. The graphic design and the Windows look & feel of the user interface allow for an intuitive use of the cockpit. During the entire project, the development was accompanied by the consideration of several applications: the molecular shaping of polymers (IGB), the 3D display technology (HHI), the organic light-emitting diodes (IAP), and the multilayer X-ray optics (IWS).

The project results were presented at the end of October 2008 during a technology forum in Stuttgart in front of numerous industrial representatives, attracting very large interest. A more detailed description of the results is given in the book "Fokus Technologie – Chancen erkennen, Leistungen entwickeln", edited by Hans-Jörg Bullinger, President of the Fraunhofer-Gesellschaft.

For the year 2009, we are planning to complement the prototype methods cockpit by additional functionalities and to evaluate it by the development example of the organic light-emitting diodes.

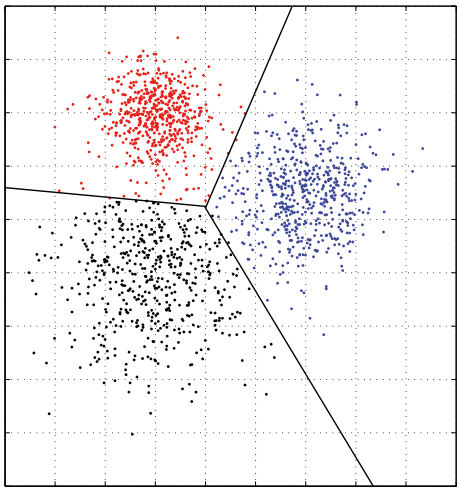


Section of the methods cockpit

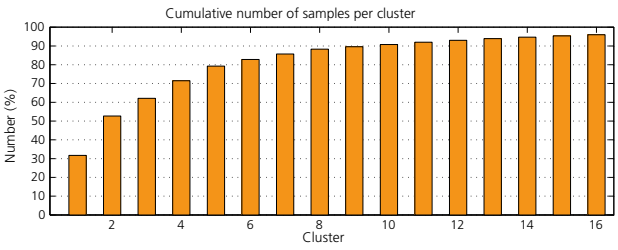
Management of product variations

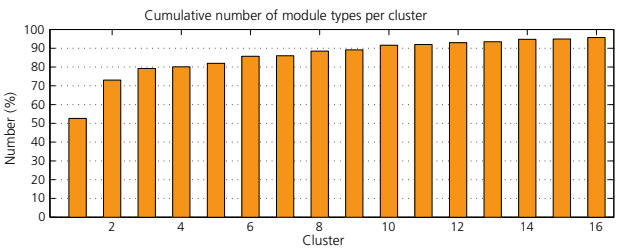
Products like cars or electric appliances are offered in many variants by the producers. Their production is thus modularized to a high degree; variants are produced based on the combination of different types of modules. The possibility of individual product configuration partly also results in the adaptation of the marketing of this production method. Different strategic questions thus focus on the "correct" selection of the set of used module types: high market coverage and the fulfillment of customer desires on the one hand and the minimization of storage and production expenses on the other. Another problem is that the structure of already existing production plants must be taken into account when designing new product families. Data mining within the respective production and customer data may be helpful in this context for the development of a strategy. The methods used are established ones, such as association rule mining or cluster analysis; depending on the context, these are modified or complemented, e. g. by graph-theoretical methods. The respective competences have been developed in the department during the last few years in the framework of different projects. In 2008, scientists of the department were able to cooperate in a project together with the company Volvo 3P, concerning the variants management of trucks (in cooperation with the department **Optimization**, cf. page 55).

Trucks have a wide range of possible applications, from the transport of goods and the work on construction sites to agricultural applications; a truck is therefore constructed on the basis of several hundreds of modules. Each of these modules has ten different characteristics on average. Simple examples of such modules are the motor, where the producer, the engine power, and the type of fuel can be selected, or the radiator grille, where the geometry or color may vary. During the project, we analyzed a vast amount of complete customer specifications for the respective truck which had been ordered. Our intention was to examine the segmentability of the data into groups of similar specifications, and to determine representatives of the individual groups, if possible. The segmentation is carried out automatically on the basis of an appropriate cluster method and a mathematical definition of similarity. The results may be helpful for the optimization of the set of module characteristics used, generally allowing for an insight into the structure of the complex, high-dimensional specification data. The project was carried out in cooperation with the Fraunhofer-Chalmers Research Center (FCC) in Gothenburg.

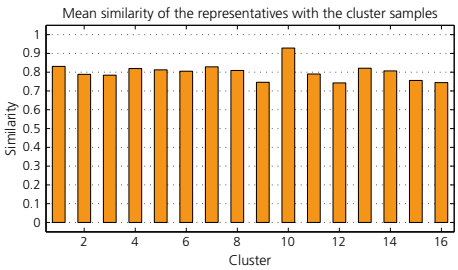


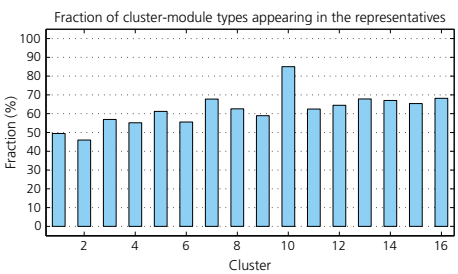
Result of the cluster analysis of a two-dimensional data record





Visualization of the segmentation of 1,000 artificial product specifications into 33 clusters (16 of these shown here)





Visualization of the quality of representatives for the clusters shown left

Carmelo Vicari, Dr. Patrick Lang, Dr. Hagen Knaf, Dr. Andreas Wirsen, Dr. Jan Hauth, Dr. Julia Orlik, Hans Trinkaus, Richard Avuglah, Dr. Alex Sarishvili, Dr. Alexander Dreyer, Alexander Nam, Thomas Halfmann, Anna Shumilina, Christian Salzig, Oliver Schmidt

Optimization

The central task of the Department **Optimization** is the development of individual solutions for planning and decision problems in logistics, engineering, and life sciences, in close cooperation with partners from research and industry. The methodology is characterized by a close coupling of simulation, optimization, and decision support.
Simulation comprises the building of mathematical models accounting for constraints, design parameters, and measures of quality and expenses to be optimized. The development and implementation of application and customer specific optimization methods for the computation of optimal solutions for process and product design belong to the main competences of the department. Special features are the close coupling of simulation and optimization algorithms by optimization-based discretization methods especially accounting for multicriteria approaches, as well as the development and implementation of interactive decision support tools. Instead of considering the optimization only as a mathematical problem, we rather understand it as a continuous process which is supported by the Department through the development of adequate tools. The main research subjects are:

Optimization of Company Structures and Processes

The portfolio comprises consulting and support with respect to the modeling of logistic concepts as well as the development of individual software components. Solution proposals for decision support are developed on the basis of optimization methods in individual software tools; these proposals are supposed to offer the best compromise between the competing planning targets of "minimization of expenses" versus "maximization of service quality". The methodology is based on event-discrete simulation and combinatorial optimization; we are dealing with efficient strategies for the supply chain management, with layout and load balancing for production and material flux systems, with models and algorithms for the planning and disposition of processes in hospitals, such as patient transport and operation scheduling, and with the mathematical modeling of strategic and operative planning tasks in public transport.

Optimization in Medical Therapy Planning

The weighting between the prospect of healing a severe disease and the avoidance of complications during therapy planning results in difficult daily planning tasks for physicians. The main research subject Interactive Therapy Planning develops new methods for clinical radiotherapy planning on the basis of multi-criteria optimization. Within a joint research project in cooperation with the Massachusetts General Hospital, the German Cancer Research Center, the Fraunhofer MEVIS, and the commercial partners Prowess Inc. and Siemens Oncology Care Systems, the research group is developing a new optimization and evaluation tool for radiotherapy planning, which enables medical physicists and physicians involved in the treatment to weigh the chances and risks of radiotherapy in a particularly simple way.

Optimization in Virtual Engineering

The application of mathematical optimization methods in engineering is based on the modeling of physical relations and technical processes and their simulation by computer programs (virtual engineering). Optimization supports engineers with respect to the design of products and processes in such a way that the targets regarding quality and costs are balanced in the best possible way. We are currently working on projects from the areas of electronic design, cutting of gemstones, design of chemical processes, layout of adsorption refrigerators, optimization of milling pro-

cesses in steel industry, and cooling of molds used for injection and pressure molding. Within each project, software components are developed for simulationbased optimization, which are able to solve the high-dimensional problems by applying especially developed integration methods of simulation and optimization algorithms. Interactive decision support tools present product and process layouts, which have been subject to multicriteria optimization, to the decision makers for evaluation and selection.

The year 2008 was characterized by strong economic growth; we would like to mention in particular:

- the establishment of a fully automatic industrial process for the production of colored gemstones in cooperation with Paul Wild GmbH Kirschweiler
- support of the company BASF SE with respect to the maintenance of its algorithms for the simulation of chemical process layouts
- the acquisition of the company proAlpha GmbH in the field of production scheduling and of the Dalli Group in the field of supply chain management as new customers
- the continuation of the cooperation with Volvo 3P (Gothenburg) as to the chassis configuration of trucks
- the delivery of radiotherapy planning components to the companies Siemens and Prowess for the preparation of the market launch

From a scientific point of view, the highlights were, apart from five PhD projects which have been concluded, the continuing support of the project "Multicriteria IMRT planning" in joint cooperation with the Harvard Medical School / Mass General Hospital (Boston) by the National Institute of Health, as well as the honor of being mentioned on the title page of the SIAM News considering the mathematical modeling and the development of algorithms with respect to the volume-optimal processing of gemstones.

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Main Subjects

- optimization of company structures and processes
- optimization in medical therapy planning
- optimization in virtual engineering

The competition "Mathematik bewegt – steig ein" was promoted not only in the especially designed "Year of Mathematics Bus", but also in all the other public transport buses in Kaiserslautern. Every month, mathematical problems had to be solved which were all somehow connected to Kaiserslautern – from the best position of the sprinklers during the Garden Exhibition and an optimal sightseeing tour through the city to the rescue (i. e. the non-relegation) of the soccer club 1. FCK.

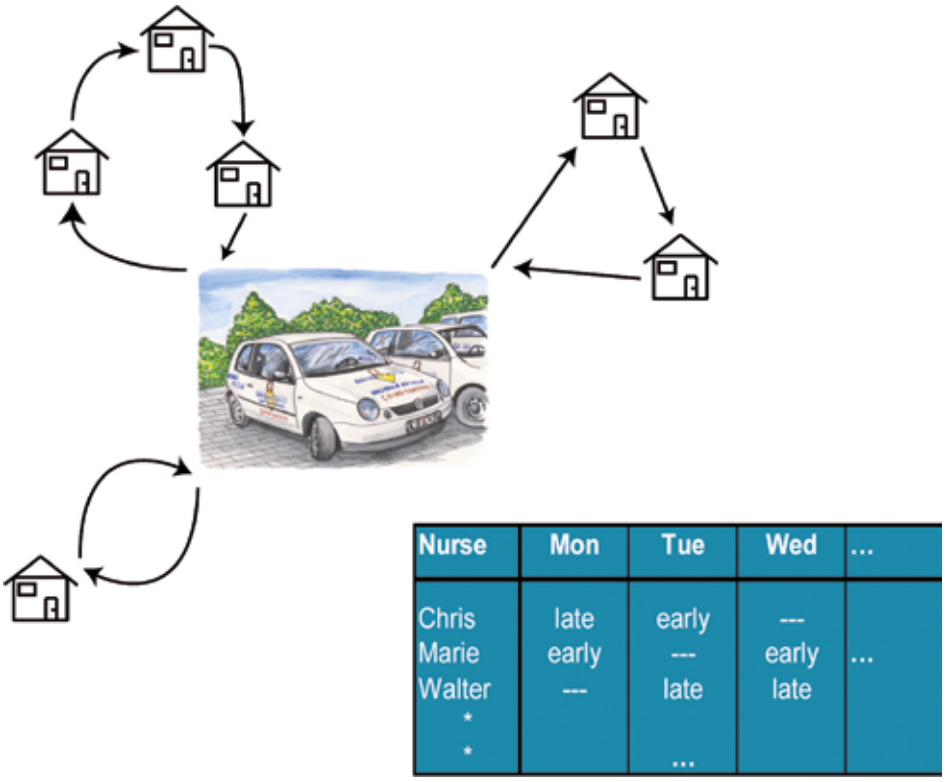
Planning for outpatient nursing service providers

In the year 2008, a PhD project titled "Mathematical Models and Algorithms for Home Health Care Services" has been concluded successfully. The research work was focused on the crew scheduling and route planning for outpatient nursing service providers. Outpatients do not only receive nursing services, but also other services like the delivery of a hot meal, or household services such as cleaning or shopping. In the light of the high costs arising from inpatient nursing and the growing number of elderly people, outpatient nursing service has become an important pillar of the health care system.

In Germany, outpatient nursing service providers usually operate in units of small or medium size up to seveal dozen of (mostly female) employees. The scheduling is subject to similar conditions as in nursing homes. Nursing services must be provided around the clock, nurses are working in shifts, requirements of labor law must be fulfilled, desires with respect to preferred working hours should be accounted for, etc.

The essential feature of outpatient nursing service is, however, that services must be provided on site, i. e. in the patient's apartment; especially in rural areas, this means that considerable distances must be covered. The respective travel hours of the personnel are considered as working hours and must be accounted for during the scheduling. An additional route planning for outpatient nursing service providers is therefore required, i. e. the linking of the nursing services for different patients with respect to location and time.

Many authors have already dealt with one of the two problems, crew scheduling or route planning. However, the requirement of outpatient nursing service providers to deal with both planning aspects within an integrated approach has much less been accounted for yet. The objective of the PhD project therefore was to examine models and optimization methods for the integrated planning problem, and to develop these further.



Outpatient nursing service providers have a task of planning, which integrates serving and route planning.

First, a coupled model was developed which was based on the ideal fact that no conditions are given, except for the shift schedule. A schedule must be planned for all the employees saying which patients to visit at which time. Main requirements are to account for the working hours in the shift schedule and the time windows agreed upon with the patients concerning the nursing service. Besides, the different qualifications of the employees play an important part; the work of the nurses should be restricted to the complex nursing tasks, whereas simpler services can also be provided by other aides. A schedule is good if each patient is visited by as few different employees as possible (over time, a relationship of mutual trust can thus be established), if no or only very few extra hours are required, and if the entire route length is minimized. The model accounts for these aspects within a mixed target function; an individual hybrid algorithm has particularly been developed for the solution, combining methods of constraint programming with the adaptive large neighborhood metaheuristic which has only recently been proposed.

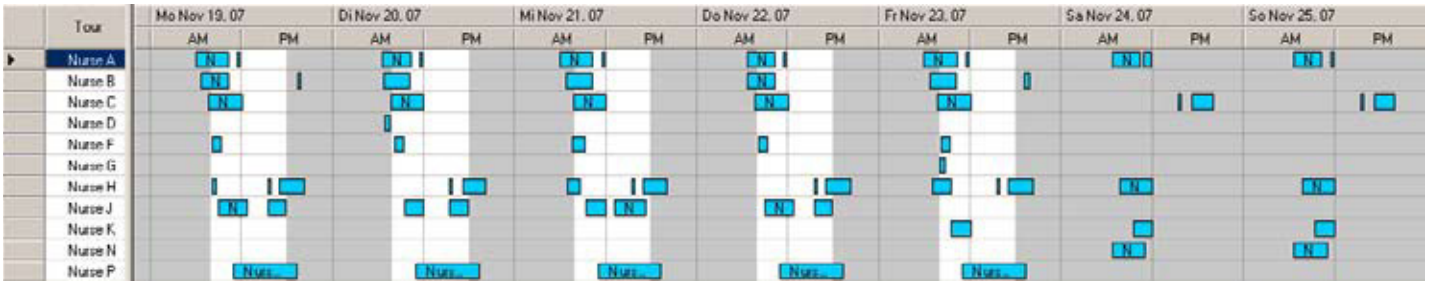
However, the ideal planning situation described above often does not occur in practice. Instead, we have a framework route planning on a weekly basis, which is adapted to the requirements of the following week during a weekly schedule meeting. This procedure takes into account that the fluctuation

of individual nursing cases is not too high. In order to support this practice, we have developed a second model for the computation of a framework route planning. Its task is to connect the individual nursing cases with respect to location and time in the form of routes. Each route must be covered during one shift, and the profile of required qualifications should be consistent. The number of routes ought to be minimized. A new algorithm based on constraint programming has also been proposed for this optimization problem.

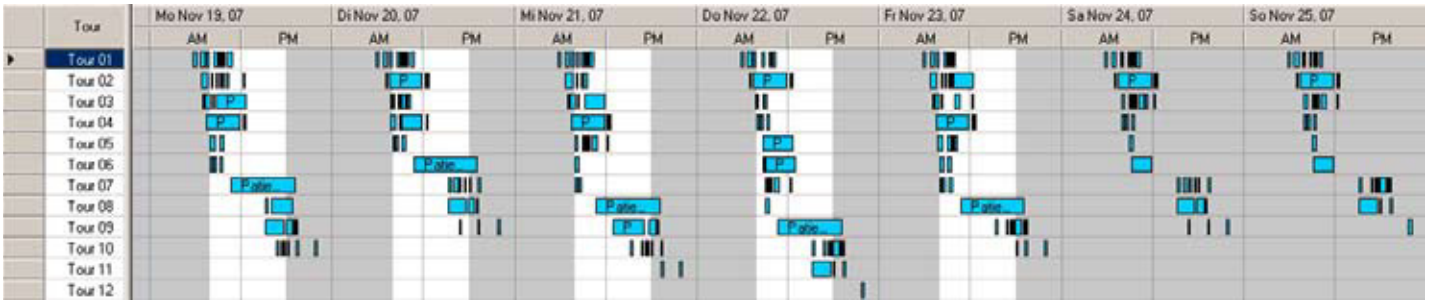
Short-term changes of the orders on hand occur daily, for examle if patients have to be hospitalized or move to nursing homes. The schedule and route planning must be adapted accordingly. This planning task on a short-term time scale has also been examined during the PhD project. First, it was necessary to analyze which events required an adaptation of the route planning. A solution strategy also based on mathematical optimization was subsequently proposed for selected types of events. An important criterion is to keep the deviations from the original route planning as small as possible.

The models and processes were then tested on the basis of data sets stemming from practical cases. The number of orders per route is equal, except for route 12 in the computed schedule, which only consists of one order. This can be assigned manually to another route; the maximum route length will only be violated marginally. Besides, the computed schedule fulfills the requirements very well.

Three routes in a rural area: the travel hours cannot be neglected and must be accounted for during the combination of nursing orders in the form of a route.



The framework route planning applied in practice



and the framework route planning computed by the model.

Decision support for the planning of chemical production plants

Motivated by an order of the company BASF SE (consulting as to the numerical treatment of systems of equations for the simulation of chemical production plants), an internal research project with respect to the decision support for the planning of chemical production plants was initiated in 2008. The software to be developed is supposed to help the chemical engineer by the possibility of an interactive determination of the optimal layout of a plant, accounting for all the relevant objectives.

A simple example of chemical production processes is the production of bioethanole, where high-proof alcohol can be produced on the basis of low-proof alcohol produced by bacteria. The plant is considerably more complex than its counterpart in a schnapps distillery, because the required pureness of the ethanole cannot be reached by simple distillation. This complexity also makes the layout of the plant more complicated.

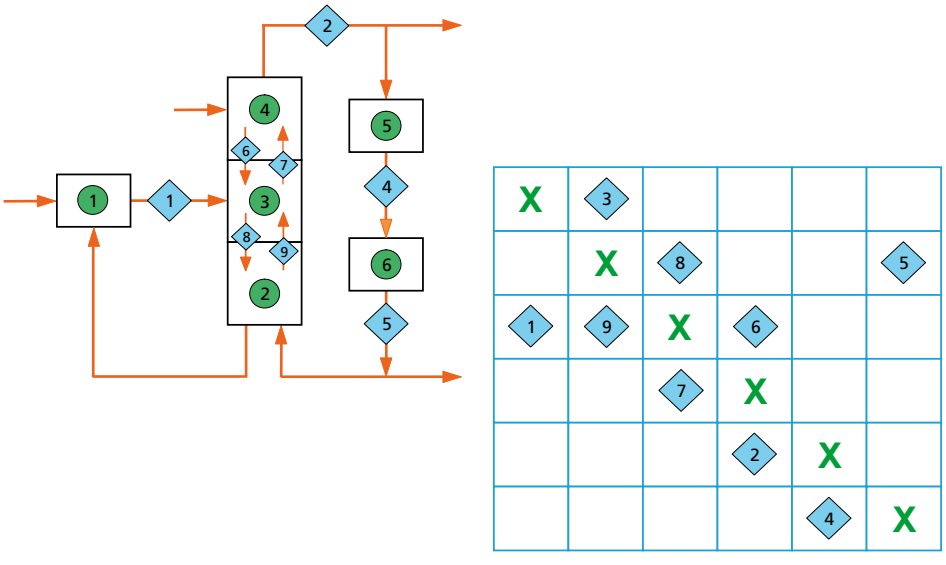
The high expenses caused by experimental plants have lead to the development of high-performance simulation software already very early. Instead of working on a molecular level, the software works on the basis of simplified models in order to make sure that the simulation remains manageable and provides sufficiently exact results.

From a mathematical point of view, two problems must be solved during the plant design: the layout problem, where the structure of the plant must be determined, and the control problem of finding the appropriate operation parameters for a given structure of the plant.

A special feature of the Department is the application of multicriteria optimization, where different and even flicting objectives can simultaneously be accounted for: with respect to the bioethanole production process, a high quality of pureness of the final product must be guaranteed; simultaneously, the required energy consumption should be kept as low as possible for an economic operation of the plant.

With the expert knowledge of a chemical engineer and by the application of the respective simulation software, the planning of such a plant becomes very simple; however, it is not always easy to account for all the objectives. This is where the optimization-based decision support comes in. Controlled by optimization, the software searches for solutions fulfilling the different target criteria as well as possible. On the basis of their expert knowledge, chemical engineers can navigate through the computed solutions and select those which represent the best compromises according to their experience; or they can look for similar results in the vicinity of a solution which may correspond better to their desires. In such a way, it is not only possible to avoid many simulation runs with different input parameters; moreover, solutions are found which would hardly have been found on the basis of a manual modification of the input parameters. The decision support can thus lead to improvements of the layout process with respect to rapidity and quality.

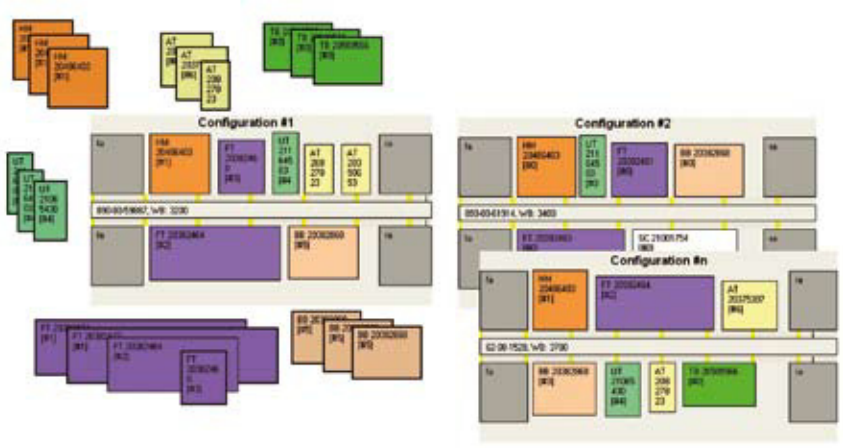
Ammonia production plant of the company BASF



The complex interlocking within a plant leads to especially structured systems of equations.

Volvo 3P ChassisPack - Reduction of variants in truck chassis packaging

The project Volvo 3P Chassis Pack, initiated at the beginning of 2008, is a cooperation of the department **Optimization** with the Fraunhofer-Chalmers Research Centre on behalf of the utility vehicle producer Volvo Trucks in Gothenburg. The project is motivated by the combi-natorial variety of configuration variants typically occuring in product development. The administration of a large number of variants causes high expenses with respect to time and money, whereas individual customer demands cannot be fulfilled as desired. The producer aims at reducing the number of configurations with respect to part selection and positioning, simultaneously maintaining all market-relevant options such as tank volumes, number of axles or towing capacity.



Variety of variants of truck chassis configurations.

Decision support for the selection of configurations with maximum tank volumes: on the left, the reference configuration of the engineer, on the right, the configuration with maximum tank volumes

The project is intended to support the truck chassis product development by means of a software solution combining problem modeling, solution search via multicriteria optimization algorithms and the administration and visualization of the found solutions.

During the first project phase a data model was developed and the simple packing problem solved. Subsequent to this first step, the optimal position of product parts such as tanks, mufflers, battery boxes and spare wheel carriers can be calculated automatically. The resulting solutions can be compared with respect to user-defined objectives such as tank volumes, deviation from a reference solution or ground clearance. The formation of a database containing a large number of variants can be simulated. Within the next step, the problem of reduction of variants was examined. Different approaches from the area of engineering design were compared, concerning specifically product family and platform design. We have developed a method for the identification of platforms for truck families, as well as an algorithm for the determination of configurations with maximum fuel tank volumes.

At the time of conclusion of the first project phase, Volvo Trucks has been able to model families, specifications and constraints with the demonstrator ChassisPack 1.0, to generate sets of solutions automatically and to find platforms for these solution sets, i. e. partial configurations of add-on parts which are common to as many solutions as possible and simultanously enable a desired variety in the solution space.

On the basis of the presented results we can continue to work on the platform identification problem with improved algorithms and production data.

Decision support in electronic design

Due to the growing demand for small and high-performance electronic devices, the development of electronic circuits is increasingly characterized by miniaturization. The engineer has to decide whether to realize the circuit in the form of an expensive integrated circuit or to work with standard components connected by a substrate (circuit board). Modern technologies like System-in-Package (SiP) also make use of the third dimension by a vertical layer structure.

The design of an SiP is a multicriteria optimization problem. Important indicators are the volume utilization, the entire length of electrical conductors, and the number of vertical interconnections for bonding the layers. Besides, there are many other design requirements based on the expert knowledge of electrical engineers.

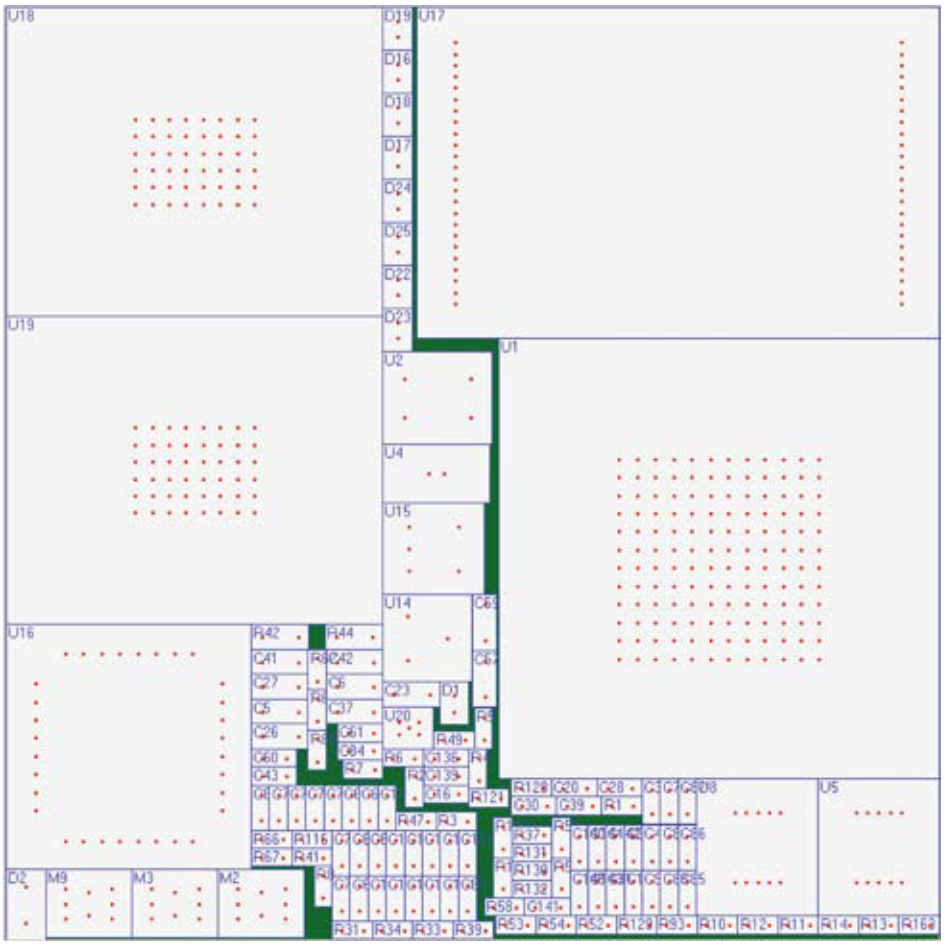
Up to now, there is no automatic placement software for SiP. However, the three-dimensional design aspect represents a complex challenge for the engineer. SiP design is therefore the objective of the research work – which is currently supported by an economically oriented strategic alliance (WISA) and the BMBF (Federal Ministry of Education and Research) project VerSiPlektor – and aims at developing an automatic decision support system. Due to the variety of the criteria, each solution represents a compromise; it is thus impossible to automatically create a layout which is perfect in all creteria. Instead, the software offers a variety of solutions to the user for interactive navigation and selection.

The automatic design optimization is divided into three essential phases:

During partitioning, the components are assigned to the individual module sides, and the required vertical interconnections are computed. During placement, the components are positioned on the module sides. During the routing phase, the conductor paths on the substrate are determined.

A main subject of the past year's research work was the examination of algorithmic approaches for the two-dimensional placement of the components. The developed insertion heuristic arranges the components successively on the given module side, thus iteratively constructing a placement. Gaps which are determined by already placed components are used for insertion; arbitrary positions are only assigned in exceptional cases. This procedure drastically reduces the number of positions to be examined, thus contributing to the method's efficiency. During the placement, also a constraint programming model rules out further inappropriate gaps.

We have been able to prove empirically that this method provides almost optimal solutions within only a few seconds, whereas exact optimization methods fail already for small circuits. In the future, the research will focus on the development of algorithmic approaches for the optimization of the wiring and on the integration of additional thermal and electromagnetic aspects.



Exemplary placement of a real data setconstructed by the heuristic

Priv.-Doz. Dr. Karl-Heinz Küfer, Martin Berger, Dr. Anton Winterfeld, Dr. Michael Schröder, Dr. Alexander Scherrer, Andreas Dinges, Hendrik Ewe, Dr. Sebastian Velten, Dr. Agnes Dittel, Tabea Grebe, Dr. Philipp Süß, Dr. Martin Pieper, Volker Maag, Jasmin Kirchner, Olga Gluchshenko, Dr. Jörg Steeg, Ingmar Schüle, Dr. Michael Monz, Uwe Nowak, Dr. Eva-Maria Kiss, Jan Schwientek, Richard Welke

Financial Mathematics

The department **Financial Mathematics** deals with model development and algorithms for the pricing of financial derivatives and for the valuation, optimization, and risk assessment of portfolios, as well as with the analysis of special risks (e. g., credit default risk). These topics are complemented by the application of modern methods of financial mathematics with respect to problems of insurance companies, especially concerning the asset liability management. Main subjects are the analysis of (financial) mathematical models, the numerical implementation of pricing methods, and the development of respective software tools. Projects typically comprise the development, examination, and comparison of financial mathematical models from a theoretical and practical point of view. Industrial partners of the Department come from, e. g., investment banking and asset management, State banks and specialized commercial banks, insurance companies (especially pension funds), and consulting enterprises specialized in banks and insurance companies. We have focused on the following main subjects:

Option pricing

Options or derivatives are derived securities whose actual payment depends on the price development of an underlying, such as stocks or interest rates. We examine innovative market models (stochastic volatility models, Bergomi model) which are able to represent actual market prices very well and to reflect the price development of the underlying securities in a sufficiently realistic way.

Portfolio optimization

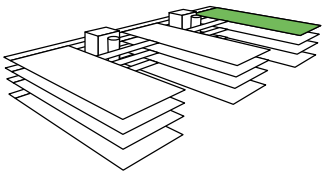
Portfolio optimization deals with the determination of an optimal investment strategy: an investor must decide how many shares of which assets to hold when. Investment decisions of fund managers are in practice often based on variants of the single period model of Markowitz. However, the development of modern, continuous-time portfolio optimization has meanwhile advanced so far that many of these new algorithms can now be considered for practical application and implementation.

Credit risk and credit derivatives

The ITWM assists financial institutions in implementing the regulations of the new Basle Capital Accord (Basle II) from a statistical point of view. In the area of credit rating or scoring, we deal with the validation of already existing bank-internal rating systems, as well as with their reconception and recalibration. The adaptation to the portfolio of the respective financial institution and the support during a later back- and stress-testing are especially important for the implementation. Credit derivatives are products based on credits; their payout depends on these underlying credits being serviced. The current financial crisis was triggered off especially by the wrong validation of such credit derivatives. Bankers have blindly trusted in available mathematical models which were, however, insufficient. Besides, empiricism in this area was inadequate until recently. Credit defaults correlated in such a significant way as on the American real estate market have never been observed before in history. Parameters have therefore been adapted systematically wrong. It has thus become clear that the mathematical models which have been used here are not yet able to describe the market in a sufficiently correct way. Particularly for those models applied for the validation of complex products with several underlying financial titles (basket default swaps, CDOs, CDO squared), there is a large demand for improvement.

Insurance mathematics

Asset liability management (ALM) is an important aspect of company manage-



ment, especially also in the framework of the future solvability regulations for insurance companies (Solvency II). We have developed the software ALMSim for the support of insurance companies with respect to the implementation of these regulations; it allows for the individual modeling of assets and liabilities, as well as for their coupling.

Interest rate models

There is a variety of interest rate models which must be examined and selected as to a possible application depending on the product and the underlying interest rate. A particularity in this area is the large number of complex interest rate derivatives. We are examining different models for the pricing of complex interest rate derivatives and their algorithmic implementation.

In 2008, the number of employees of the department has grown considerably. Apart from consolidating economic returns, we have increasingly concentrated on acquiring public and internal project funds which primarily ensure preliminary research. In cooperation with research groups of the University of Kaiserslautern and of the Universities of Karlsruhe, Oldenburg, and Ulm, the department participates in the joint research project "Alternative Investments: Modeling, Statistics, Risk Management, and Software", supported by the Federal Ministry of Education and Research. An individual research project for the validation of stock option programs, oriented on SMEs, has also been initiated in 2008. The project "Application of Modern Portfolio Optimization Methods in Practice", which is funded by the "Stiftung Rheinland-Pfalz für Innovation", has been continued.

In particular, the year 2008 also stands for the beginning of a reinforced international cooperation of the department. Within a series of talks and workshops, research results and application projects were presented at different universities of the Australian Financial Integrity Research Network (FIRN). However, a special highlight is the intensive cooperation with the University of Cambridge, initiated at the beginning of 2008. Our partner is the renowned financial mathematics research group; we are primarily cooperating with respect to continuous-time portfolio optimization, simulation software, and risk management.

Main subjects

- option pricing
- credit derivatives
- credit risk
- portfolio-optimization
- insurance mathematics
- interest rate models

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"Atrium Jazz" was played during the finissage of the exhibition "Imaginary – with the Eyes of Mathematics" in the middle of April; the band "Jazzversity" created a relaxed lounge atmosphere in the roofed atrium, contributing to a beautiful conclusion of a well-frequented exhibition.

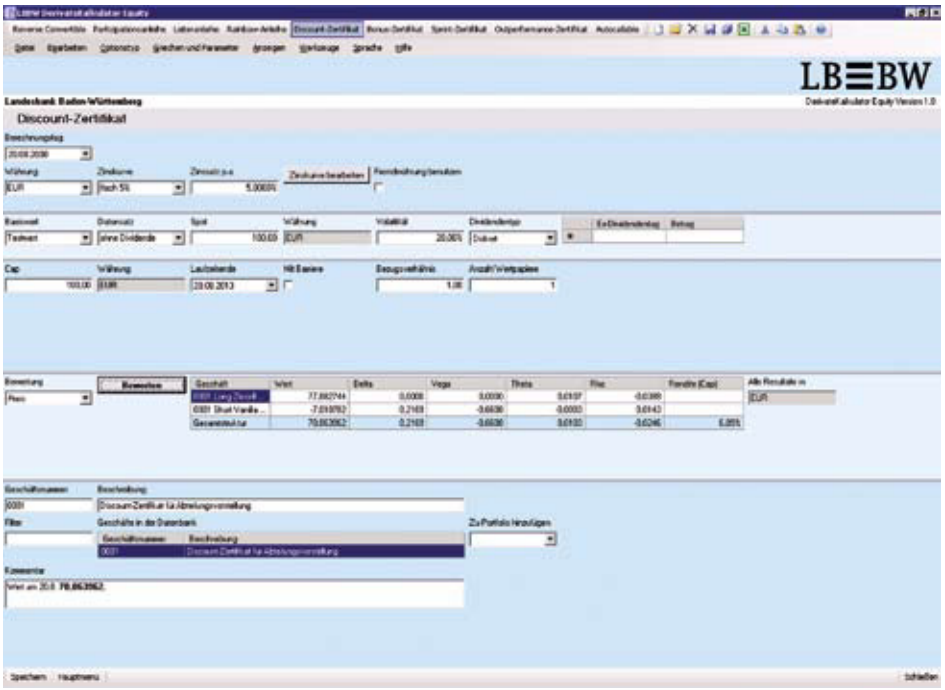
Option pricing tool DeriKE

The pricing of standard options on the basis of the Black-Scholes model today belongs to the basic knowledge of each financial mathematician. However, if we look for a software tool which, beyond that, is able to price more or less exotic options, simultaneously being easy to handle by the user, we will soon come to a limit. Within a project carried out for the Landesbank Baden-Württemberg, such a software tool for the pricing of very different options and certificates has been developed on the basis of the Black-Scholes model.

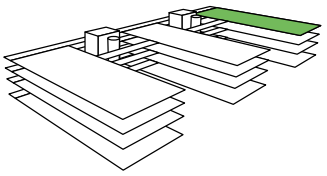
The tool offers a variety of functionalities: from the input of market data from external CSV files and their storage within a data base and the pricing of standard and exotic options, as well as standard certificates and types of bonds, to the storage of individual transactions in the data base and their aggregation and analysis in portfolios. Modern computer architectures are used for parallel computing. In addition to the fair price of a product, the software also computes usual risk parameters, such as delta, vega, etc., as well as expected returns of investment products.

Compared to other pricing tools, the software developed here is primarily characterized by its strong orientation on practical requirements. For example, the expected dividend payout is accounted for during the pricing of every option, the use is intuitive and clear, required parameters such as interest rates, exchange rates, correlations, etc. can be fed in directly and saved between sessions. Besides, complicated financial products are taken apart, and their individual components are priced separately. The possibility of exporting the used and computed data automatically to an Excel file perfectly fits into the Windows interface of this tool.

From a mathematical point of view, this project also presented us with several challenges. The payout of discrete and known dividends has been accounted for continuously on the basis of a new model. Different already existing pricing methods have been adapted, revised, or even completely redeveloped for this purpose. Besides, special emphasis was put on the consideration of the special effects occurring during the pricing of options on highly volatile stocks. This particularly concerns the extreme skewness of distribution of such a stock price.



Pricing of a discount certificate with risk parameters



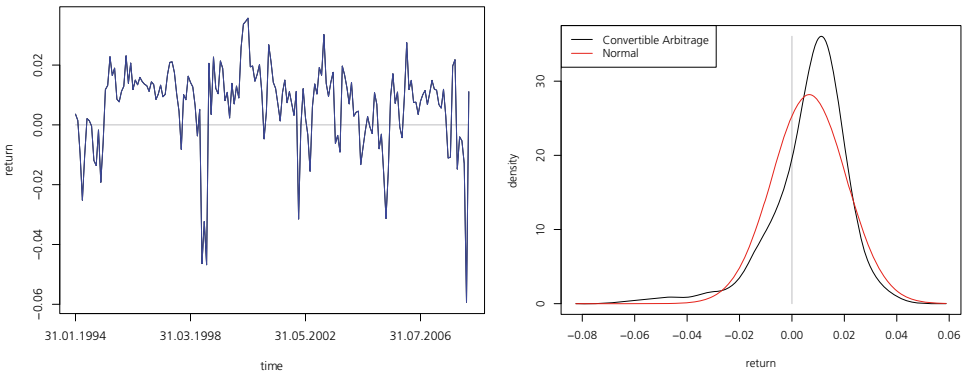
Alternative investments

Alternative investments, especially hedge funds, become increasingly important on the financial market. These forms of investment have not been regulated substantially yet, so that a risk analysis and an analysis of returns are very difficult. Within this joint research project in cooperation with the University of Kaiserslautern and the Universities of Karlsruhe, Oldenburg, and Ulm – funded by the Federal Ministry of Education and Research – the ITWM deals with the validation and statistical analysis of hedge funds, in order to enable investors to quantify the risks of alternative forms of investment.

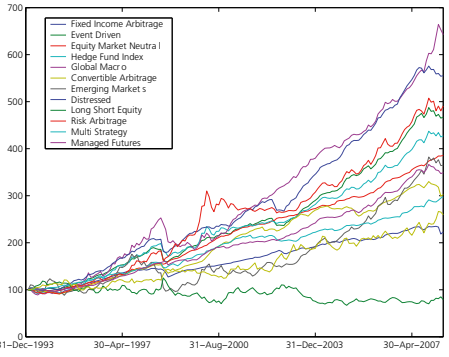
The statistical analysis of hedge fund data can almost only draw on short or incomplete time series, because the funds' returns do not have to be published. The historical return time series of the hedge funds show autocorrelation, skewness, and leptokurtosis. The empirical examination of the returns of hedge fund indices, which can be used as instruments for the modeling of hedge fund returns, also yields structural inconsistencies.

Hedge fund managers follow different trading strategies: we can distinguish between market neutral, event-oriented, and opportunistic strategies. The manager may vary his/her strategy, the investment thus remaining flexible. However, strategy changes may cause structural inconsistencies, which make a modeling and prediction of the hedge fund returns more difficult.

Within the project, a regime-switching regression model is developed in order to be able to reflect possible strategy changes of the hedge fund managers in the model. The hedge fund indices are selected as independent variables; their factors may take on several states. These factors follow a discrete Markov chain and are determined by a filter method for a hidden Markov model. The possibility of switching the regime enables the model to react more flexibly to changes of the market or of the trading strategy. In a simulation analysis, hedge fund returns have been replicated. Besides, on the basis of a more exact analysis of additional hedge fund time series, we intend to develop methods for an early detection of structural changes and the respective risk assessment.



Development and distribution of returns of the hedge fund index with the trading strategy "Convertible Arbitrage"



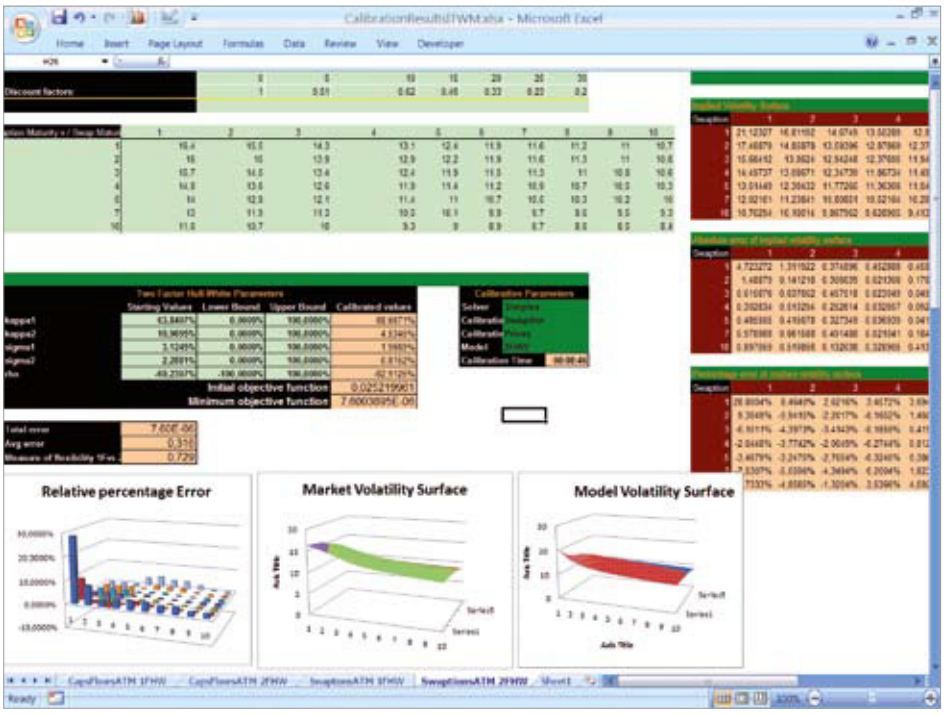
Hedge fund indices of different investment strategies

Pricing of interest rate derivatives

The popularity of stock derivatives has currently decreased a little; this is, however, not the case for interest rate products. It is, for example, very interesting for investors to take advantage of the steepening interest rate curves worldwide; investors particularly consider structured products coupled with interest rates. These are interest rate derivatives whose coupons and possible additional returns depend on the development of one or several underlyings, e. g., LIBOR, Constant Maturity Treasury (CMT) rates, or Constant Maturity Swap (CMS) rates. An interest rate derivative often pays a coupon only if the agreed upon conditions have been fulfilled. (If these conditions have not been met, the investor only receives the principal in whole or in part value.) Examples of such structured products are CMS Notes, CMS (Digital) Spread Notes, CMS/LIBOR Reverse Floater, and Range Accrual Notes.

A detailed consideration of some examples of these products shows that the payout of a CMS (Digital) Spread Note depends on the positive difference between the e. g. thirty-year and the ten-year (Euro) swap rates, whereas the buyer of a Reverse Floater profits from low short-term swap rates (mostly one to two years). The first step concerning the price calculation of interest rate derivatives is the assumption of a model for the short rate dynamics. In the case of the CMS-linked products, we need a model which can be well calibrated with respect to market cap and floor prices, as well as with respect to swaption prices ("at the money"). Typically, a model is required which is based on several stochastic processes. In addition to a good fit to market data, the model should also be easy to handle from a numerical point of view and not over-parameterized. A successful model in practice is the two-factor Gaussian model G2++ of Brigo and Mercurio, which offers a closed form solution for caps and floors and a semi-closed form solution for swaption prices.

In the framework of a project for the company Assenagon GmbH, the ITWM has implemented the G2++ model for the development of a generic price calculation tool for CMS/LIBOR-linked products. The tool has a user friendly GUI based on MS Excel, and the computations are carried out performantly within an underlying C# library. The tool requires the user to enter the initial tern structure of short rates first; the model parameters are then calibrated with respect to market caps and floors and/or a market swaption volatility. Finally, a large variety of structured interest rate products can be priced by the selection of the underlying (CMS or LIBOR), the form of the coupon, and the definition of callable or puttable options.



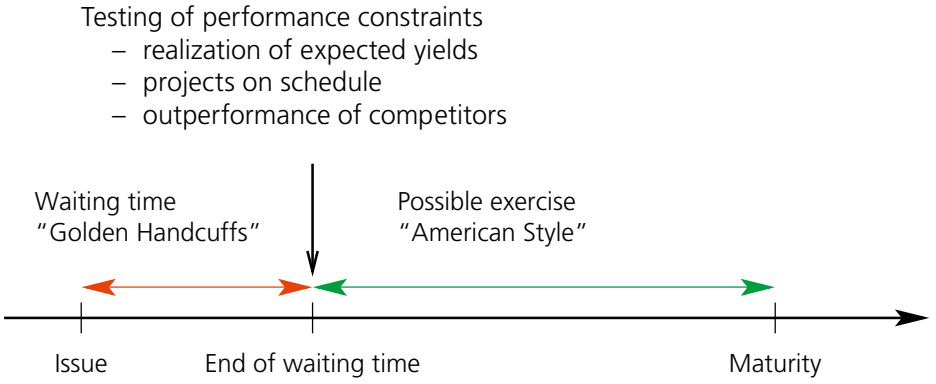
Calibration of the G2++ model with respect to the market swaption volatility

Validation and optimization of executive stock options

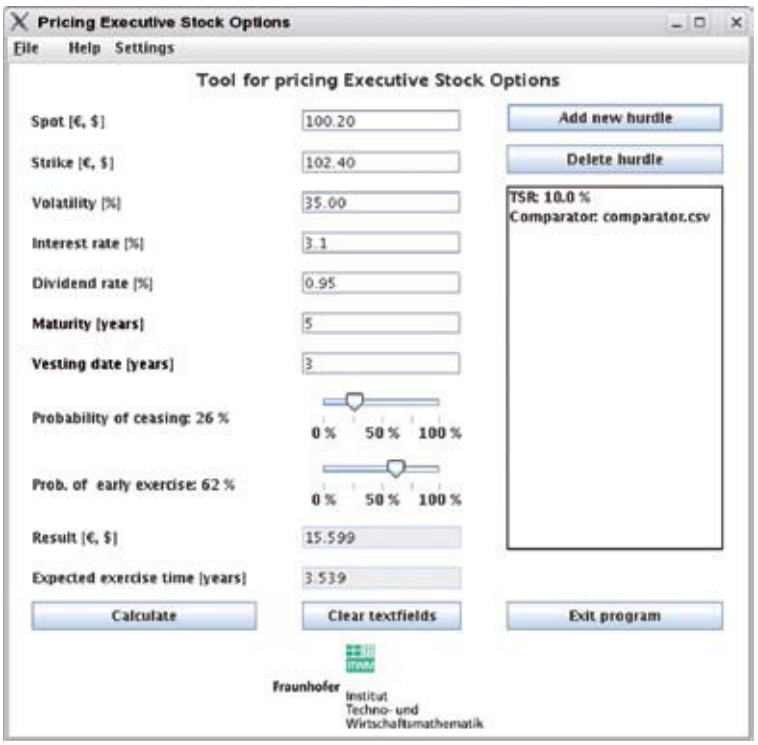
Executive stock options are a widespread means for the remuneration of employees and represent a large percentage of the salary of the executive board and board of management. Their correct balancing according to the currently used framework IFRS 2 (International Financial Reporting Standard 2) requires the determination of the fair price on a financial mathematical basis. In the year 2006, 62 of the 110 DAX, MDAX and TecDAX companies issued executive stock options for their employees. The required and balanced expenses in personnel varied between 19,000 and 650 million Euros. The relative order of magnitude compared to the profit of the company was approximately five per cent on average.

Executive stock options differ from exchange-traded options:

- they are not quoted and cannot be sold
- after a given waiting period ("Golden Handcuffs"), they can also be exercised before expiry
- they usually depend on performance hurdles which must be cleared and controlled at the end of the waiting period
- they are long-lasting, i. e. they have a duration between five and ten years



Exercise scheme of an executive stock option



Web-based pricing of executive stock options.

However, there are several deficits of the current market standard with respect to the pricing of executive stock options: on the one hand, the assumption of constant parameters, especially of a constant volatility, and on the other hand the over-parameterization in the multi-factor version and the ignorance of an early "irrational" exercise. In practice, these deficits often lead to a significantly wrong pricing; the error may amount to up to 30 per cent.

Within this project, we are developing adequate financial mathematical pricing models for executive stock options which account for the above mentioned particularities. These models are implemented in a web-based software demonstrator. The development is carried out in the framework of the project ESO (Executive Stock Options), an individual research project oriented on SMEs.

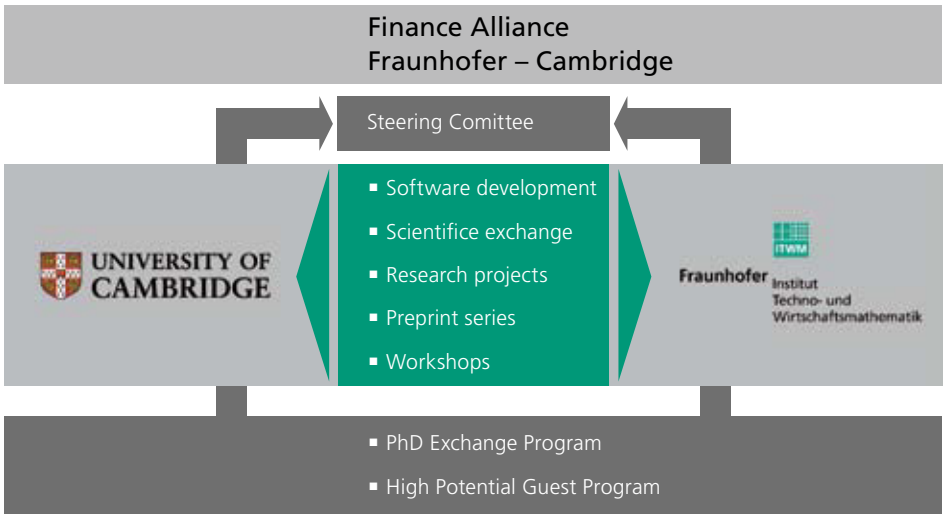
Finance Alliance Cambridge – Kaiserslautern

2008 was the first year of the strategic alliance between the department **Financial Mathematics** and the renowned financial mathematics research group of the University of Cambridge. It was focused on the cooperative development of modern financial mathematical methods, the optimization of already known methods, and the use of the know-how available on both sides in order to develop software products ready for application; besides, the alliance was presented to the banking public in England.

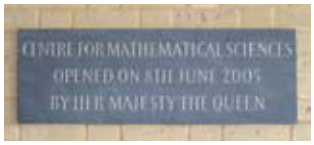
The year 2008 was an important year for the initiation of the projects in the fields of, e. g., portfolio optimization, risk management, and asset liability management by several common workshops. We have also been able to integrate the Cambridge-based company Cambridge Systems Associates Limited. Besides, several scientists of the Fraunhofer ITWM have worked in Cambridge for longer periods in order to cooperate in the research. A completely new research project has been started which is based on the explicit modeling of economic factors as the real price-determining elements. We expect information about the predictability of extreme events or breaks in economic trend.

The most spectacular event in England was the launch of the Alliance in the Brewers Hall in London on July 21, 2008. Researchers from Cambridge and Kaiserslautern presented the cooperation to the numerous participants from practice. First effects of the financial crisis have then delayed the direct introduction into the English market, because for the time being no new industrial projects have been started due to the turbulences. We expect this year to make up for that.

Finally, Philip H. Dybvig, Professor for Banking and Finance of the Washington University in St. Louis, a renowned external scientist, was admitted to the Scientific Advisory Board of the cooperation. More persons will follow in 2009. For 2009, apart from the already initiated projects we are planning additional workshops, for example a practical workshop in Kaiserslautern together with scientists from Cambridge, practical workshops in London, and the further extension of the partnership.



Structure of the Finance Alliance Fraunhofer – Cambridge



The Centre for Mathematical Sciences on the campus in Cambridge, which is modeled on a hyperbola

Prof. Dr. Ralf Korn, Dr. Kalina Natcheva-Acar, Melanie Hollstein, Roman Horsky, Eva-Maria Zimmermann, Dr. Ulrich Nögel, Tilman Sayer, Dr. Stefan Lorenz, Nataliya Horbenko, Dr. Sarp Kaya Acar, Dr. Christina Erlwein, Dr. Peter Ruckdeschel, Dr. habil. Jörg Wenzel, Dr. Gerald Kroisandt, Dr. Georgi Dimitroff, Sascha Desmettre, Priv.-Doz. Dr. Marlene Müller

Mathematical Methods in Dynamics and Durability

The department **Mathematical Methods in Dynamics and Durability** (MDF) deals with the modeling and simulation with respect to the durability and reliability of mechanical and mechatronic systems subject to dynamic loads. Applied methods are multibody system simulation (MBS), finite element methods (FEM), as well as statistical and optimization methods. Within our industrial projects, we primarily deal with reliability, durability, and structure and system dynamics in vehicle industry. We are also simulating production processes, e. g., casting processes, for the development of functional component properties.

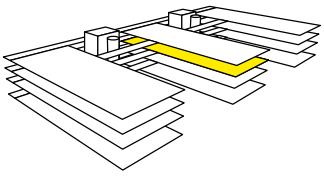
The past year was characterized by a further extension of industrial project activities. We would like to especially point out the further development of Digital engineering for commercial vehicles (www.nutzfahrzeugcluster.de), where the department has taken over the overall coordination as well as essential sub-projects. Under the direction of MDF, the work groups Statistical methods for dynamic service loading, System monitoring and load simulation, System simulation with invariant excitation, and Tire modeling for vehicle simulation have been installed in cooperation with the industrial partners Bosch, Daimler, John Deere, Keiper, Schmitz Cargobull, and Volvo; several workshops were carried out with respect to each subject. A special highlight was the 1st Conference on Digital Utility Vehicle Technology in October 2008, with more than 150 participants. Individual activities of the Department are divided into the following main subjects:

Statistical Methods in Durability and Reliability

We are developing methods for the modeling of clients' load profiles as well as for the planning and evaluation of experiments with respect to durability. Statistical methods are of central importance during the design and evaluation of components subject to mechanical loads, with a special focus on their reliability. This begins with the determination of the design targets: how do we model the client's load profile? How do we plan measurement campaigns for the determination of load data during operation? How do we translate these into reliability objectives and design targets? Finally, the experiments for the proof of durability must be evaluated by statistically secured methods. This is the case for experiments with respect to individual components, as well as for expensive long-term experiments with respect to entire vehicles.

Modeling and Simulation of Mechatronic Systems

By system simulation, we want to model complete vehicles, axles, or inspection systems of "optimal complexity"in such a way that not only the kinematics and the motion sequence, but in particular also the power transmission can be computed correctly in advance. Within the model, the interaction of a very large number of moving components must be accounted for, as well as the behavior of complex force elements and actuators. On the other hand, the modeling depth is restricted by limited resources with respect to time and hardware, and with respect to the parameterizability of the models. A main subject concerning the development of our methods for system simulation is the subject of invariant system excitation. Identification methods (iteratively learning control) and the appropriate modeling methods for external mechanical contact (tires, digital road, excavator, plows) are developed and applied here.



Structural Dynamics and CAE Durability

Such a simulation of the system dynamics provides the loads to which the individual – more or less deformable – components are subject as dynamic cutting forces. These cutting loads are then transferred to local loads and lifetime estimations by structure mechanical simulation. We particularly work on methods for lifetime computations for structures with a nonlinear behavior and apply these within industrial projects. Besides, we deal with the simulation of strongly deformable structures, such as cables, tubes, elastomeric bearings, and tires.

Component Properties Depending on the Casting Process

Foundries like the companies HegerGuss and Gienanth are using our competence in the field of casting process simulation in the framework of cooperation projects. In the case of the company MAGMA GmbH, Aachen, we are not only a user of their software, but also their development partner. Our research activities are focused on the problem of how to systematically conclude component properties on the basis of the simulation results of the casting process.

Main Subjects

- statistical methods for durability
- modeling and simulation of mechatronic systems
- CAE durability (MBS, FEM, lifetime)
- component properties depending on the casting process

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For several years now, the Modeling Weeks have been an integral part of the program offered by the Department of Mathematics of the Technical University of Kaiserslautern to schools in Rhineland-Palatinate. During the Year of Mathematics, they were also organized in Bavaria for the first time – supported by the ITWM; pupils and teachers could try out the possibilities of modern applied mathematics and find the relation to everyday life themselves. However, the modeling of tires has still remained a job for "advanced students".

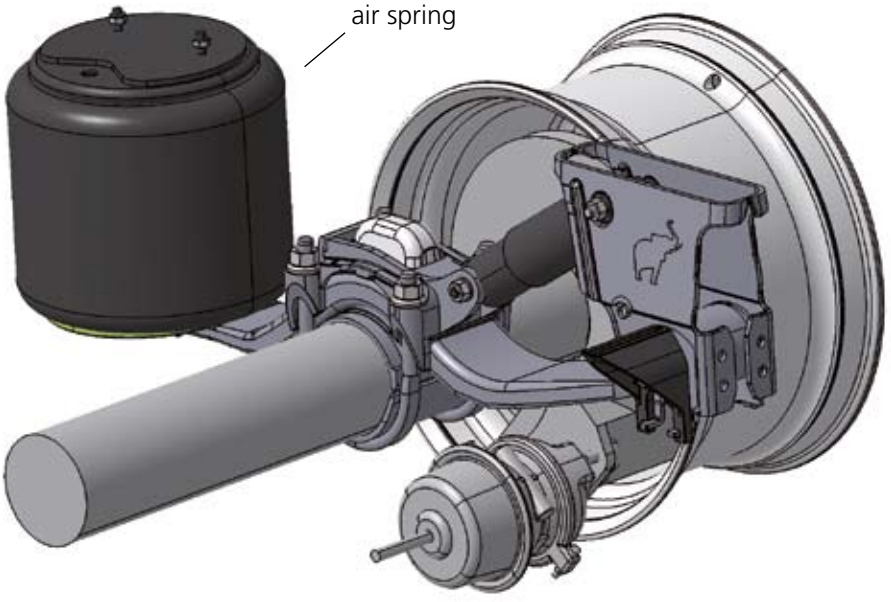
Physical modeling of the air bellows system of a semitrailer

The use of air-filled bellows as suspension elements is very common in automobile and utility vehicle industry. According to the general function, the suspension power is generated by the internal pressure of the more or less compressed air volume in the interior of the bellows. Air bellows are state-of-the-art particularly in chassis suspension systems of multi-axle trailers (semitrailers). The disadvantages of weaker robustness and higher weight compared to a leaf spring suspension system are compensated by far by the advantages of superior driving comfort (almost load-independent vibration frequency), higher driving safety, and flexible pneumatic ride height regulation.

From the point of view of a physically based simulation model for the entire system of a semitrailer, air bellows represent complex force elements in the chassis whose force development depends on frequency and temperature. In practice, one mostly wants to avoid the effort of their explicit modeling according to the underlying thermodynamic laws, settling for a (frequency-independent) simple spring characteristic.

However, in view of the central importance of the air bellows suspension for the driving behavior, the system has been explicitly accounted for in a physically well-founded way within a virtual model of the entire trailer, in cooperation with the company Schmitz Cargobull AG.

The computer simulation of the entire system is realized in the form of a co-simulation by the software Virtual.Lab Motion for the mechanical and Imagine.Lab AMESim for the pneumatic domain. The respective sub-project of the pneumatic sub-system focused on the physically based modeling and validation of the force behavior of an air bellows. Measurements were carried out for the quantitative estimation of its mechanical and thermodynamical properties. By identifying and accounting for the dominant physical effects, we have succeeded in developing a bellows model which is performant and efficient at the same time. With the help of this model, the complex suspension behavior can now be reproduced reliably for a wide range of parameters, without requiring disproportional extra computing time for the simulation of the entire model.



Right side of the rear axle construction of a semitrailer with suspension system, break, and wheel rim

Load time gradients of screws in an articulation

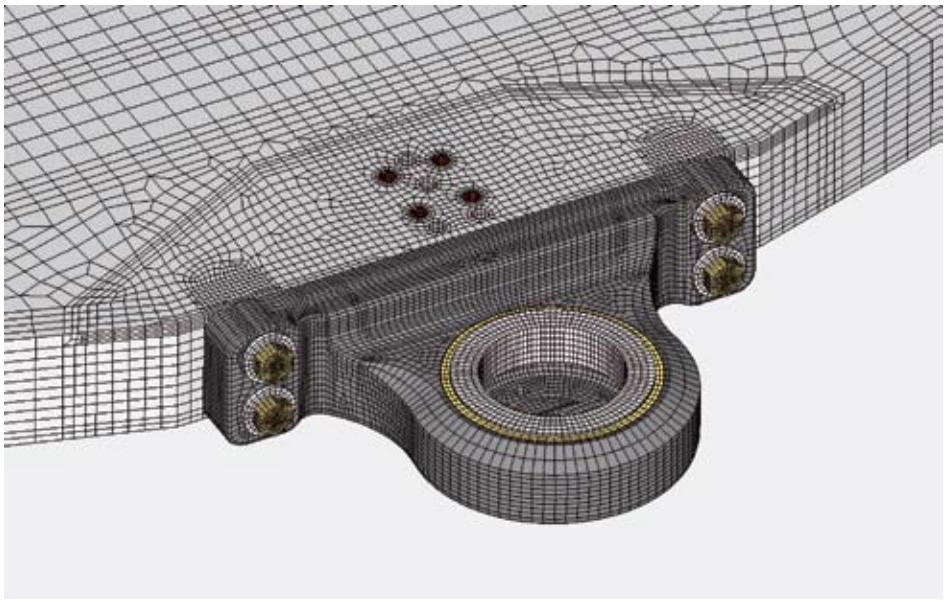
Screws belong to the most important solvable connections in constructive engineering. They are typically designed and computed analytically according to the German VDI regulation 2230, which combines all the parameters and computing steps required for durability verification, on the basis of simplified model assumptions and idealized connection geometries.

In complex cases which are not covered by the VDI regulation, other methods must be selected. In the case of the articulation of the Combino Basic train, produced by SIEMENS AG Mobility Division (Erlangen), special challenges were to account for the following effects which are not covered by the VDI regulation:

- nonlinear contact conditions between the components which are varying over time
- the articulation is subject to multiaxle and external loads which are varying over time
- high screw prestressing

The objective of this project in cooperation with SIEMENS AG Mobility Division was to carry out a life-time simulation accounting for these effects. This has not been possible with the usually applied methods (e. g., finite element method and quasi-static superposition or transient, nonlinear FEM); we have therefore developed an especially efficient method for the computation of the stress time gradients in the articulations.

The core of the method is based on an interpolation approach which allows for a very fast computation of the resulting stress within the screw shaft for all the load combinations occurring in the measurement time series. The basic idea of this interpolation approach is to compute the resulting stress distribution within the screw for a specific number of 3d load combinations on the basis of FEM analyses, and to insert these results subsequently as “grid points” in an interpolation cube for a nonlinear gradient curve.



FEM model of the Combino articulation

The resulting stress time series have then been integrated into an operational strength computation, in order to enable the evaluation of the screw connections with respect to their expected lifetime.

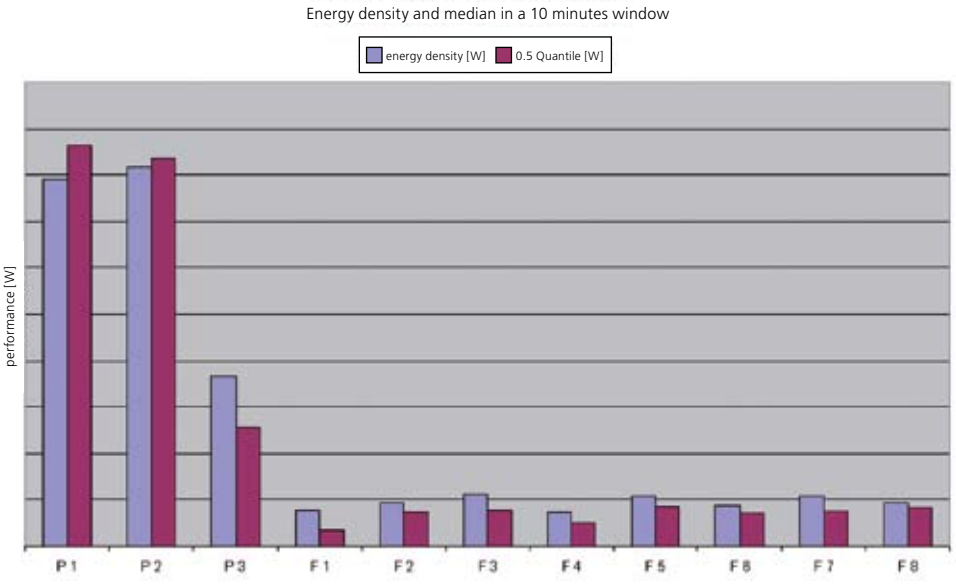
This method allows for the examination and improvement of the lifetime conditions of different construction layouts subject to complex load and contact conditions already during the phase of design; the computing times are economically acceptable.

The Combino driving through Freiburg

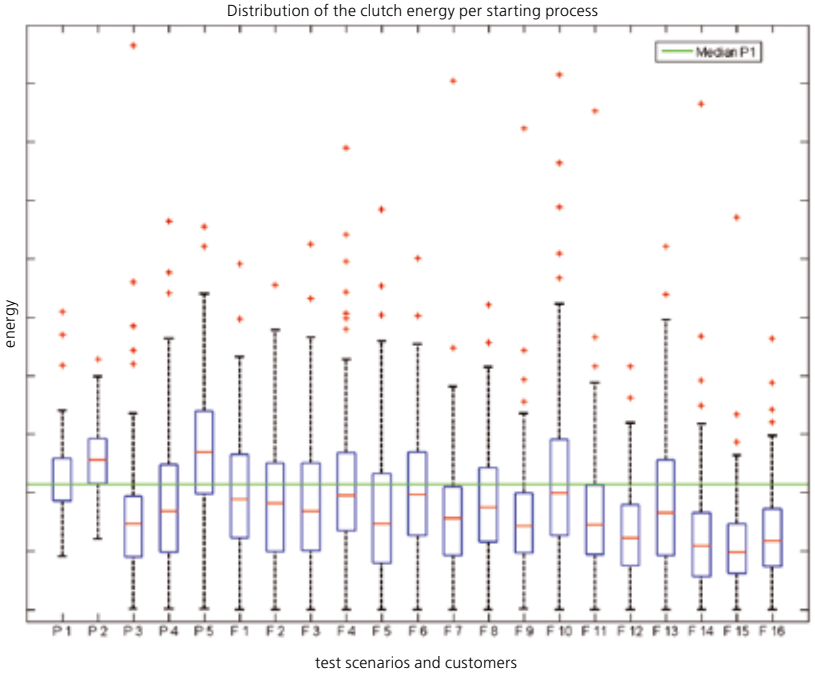
Load analysis for a car clutch

At the company GM Powertrain, a producer of motors and gear boxes, the clutch was subject to considerable loads during test programs. In order to determine the ratio for normal customer operation, the ITWM has evaluated almost 300,000 kilometers of field data which had been collected during the last two years in order to provide new information about the degree of the load to which a power train is subject at the customer. The data referred to 16 vehicles of the types Opel Corsa, Vectra, and Zafira, as well as Saab 9-3, with different power trains (motor/gear drive/differential combinations); these were equipped with devices for the acquisition and storage of data like velocity, engine speed, engine torque, and wheel speed. The vehicles were driven by 59 different drivers on German and Swedish roads under normal everyday conditions.

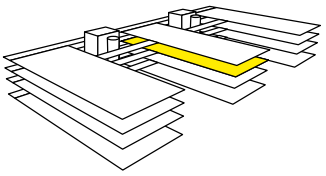
Algorithms have been developed for the analysis of the load to which the clutch is subject; these are able to compute the energy input of the clutch especially during the processes of starting and changing gears, where particularly high loads occur. A special problem was that the field data were only available in a relatively rough 10 Hz resolution; besides, specific parameters (e. g., the engine torque) were only available as indirectly computed channels with insufficient exactness (particularly during the gear changing process). The evaluation algorithms therefore had to be calibrated with respect to reference data records (with 100 Hz data and measured torques) and provided with correction formulas. The resulting energy inputs were analyzed by statistical methods depending on the driver, vehicle, and power train. Especially interesting were those evaluations with a floating average over time intervals of different length (5, 10, 20, and 30 minutes). Finally, the results were compared systematically with the analyzed test programs. The resulting information enabled GM Powertrain to shorten individual testing scenarios and to combine these within an optimal test program adapted to the customer behavior.



Performance input of a car clutch in test scenarios (P1, P2, P3) and during customer operation (F1 to F8); the bars show the average performance (blue) and the median (red) for a floating average over a 10 minutes window.



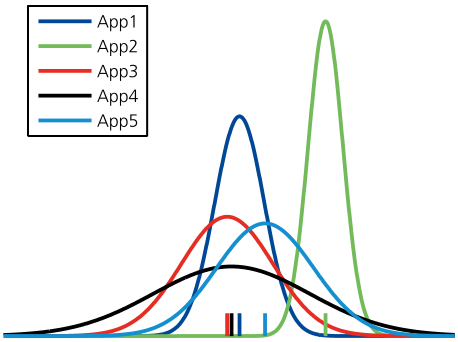
Box plots of the probability distribution of the car clutch energy, analyzed for starting processes; we can see the distributions in test scenarios (P1, …, P5), as well as during customer operation (F1, …, F16).



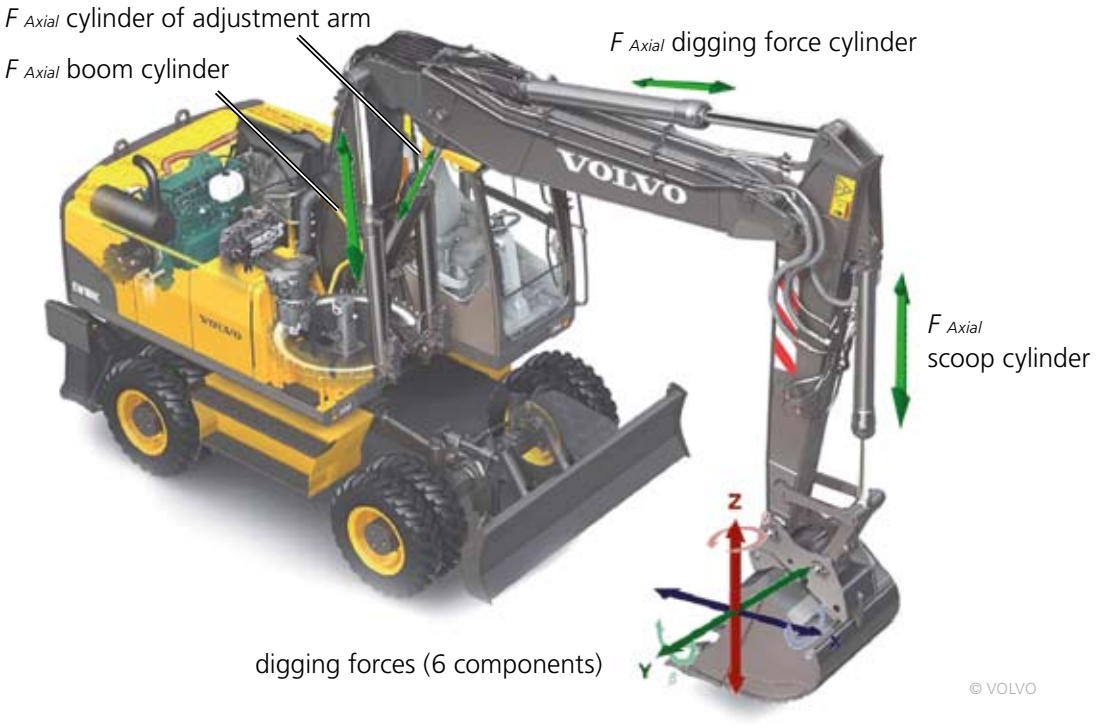
Design targets for the development of mobile excavators

The layout of machines with respect to their reliability requires the knowledge about customer load profiles. VOLVO CE has provided a mobile excavator with measurement technology in order to determine the respective load profiles; the excavator is available to different customers throughout Europe. There is a large variety of applications, ranging from digging applications and the loading of trucks to driving on rough tracks. The large differences with respect to the load resulting there from (and from additional influence factors as well) must be accounted for during measurements as well as during the analysis of the measurements. In order to evaluate the measured data as efficiently as possible and to be able to use the complete information provided by these, different statistical methods are applied, e. g., correlation analysis, variance analysis, or Monte Carlo simulations.

The ITWM supports VOLVO CE with respect to the processing of the measured data, carrying out the statistical evaluations for the derivation of load profiles. We examine, for example, by variance analysis which ones of the different application possibilities of the excavator differ significantly with respect to the load and must therefore be considered separately during further evaluations. On these grounds, factor models of the influence parameters are developed; based on these, customer populations are simulated which can be used for the layout or validation. Besides, representative measurements corresponding to a specific customer load profile can be identified by optimization methods. These measurements may then be used as input for simulations.



Distribution density of the damage distribution of five different applications with the respective average values. Applications 2 and 5 strongly differ from the other three with respect to the average value and must therefore be considered separately.



Load data acquisition (forces and torques) at the working equipment of a mobile excavator

Dynamic load simulation of utility vehicle seats

The seats mounted in current utility vehicles must fulfill high requirements. Demands as to comfort, ergonomics, and crash safety are increasing. A special challenge for the company KEIPER, a producer of vehicle seats, is the expected lifetime of utility vehicles of 1.5 million kilometers.

The Fraunhofer ITWM has developed a multibody model for a more exact analysis of the loads to which a component is subject. In different evolution steps, the model was first structured as a pure rigid body model; later it was extended by flexible structures. The dummy-seat force coupling was done by contact elements. The used contact elements were optimized multiply in order to increase computing velocity.

Within this project, a software environment has also been created which is able to evaluate and compare automatically the measured data as well as the results of the simulation. It additionally comprises the possibility to select the simulation environment, which allows for extensive parameter studies and sensitivity analyses. The resulting multitude of simulations (more than 600) was computed and evaluated automatically on the ITWM Linux cluster.

In order to prove the model quality, the real vehicle seat was examined on a shaker at the company KEIPER, parallel to the simulation; among others, transmission functions, component forces, and the resulting damages were determined and compared.

There is only very small installation space available, or the masses of measurement devices influence the results; the actual loads to which the components are subject can therefore often only be measured with considerable effort or indirectly. If we want to make a prediction about their lifetime, test rig runs must be carried out until the components to be observed will finally fail. In order to shorten the required time, the signals measured within the vehicle are summarized and amplified, serving as excitation for the test rig and the simulation simultaneously.

A complete test rig run, which usually takes several days without preparatory work, can now be computed and evaluated within approximately 20 minutes.

Test rig for the dynamic load to which seats are subject, at the company KEIPER

Virtual seat model for the simulation of the dynamic load, developed at the ITWM

Steffen Polanski, Dr. Nikolaus Ruf, Dr. Holger Lang, Thorsten Weyh, Lilli Engelhardt, Oliver Weinhold, Silke Menzel, Ilker Nikelay, Michael Burger, Sascha Feth, Dr. Dominik Jung, Sabrina Herkt, Dr. Bernd Büchler, Dr. Klaus Dreßler, Dr.-Ing. Joachim Linn, Reinhard Priber, Yekta Öngün, Dr. Albert Marquardt, Dr.-Ing. Gerd Bitsch, Dr. Anja Streit, Thomas Stephan, Sonja Baumann, Dr. Michael Speckert, Oliver Hermanns

Competence Center High Performance Computing

Due to the growing importance of simulation and the availability of appropriate software in industry, the use of parallel systems has now become standard in the commercial environment as well. Large parallel computer systems are used by financial service providers, in the oil industry, and in Formula 1 racing. Most systems today consist of standard PC hardware, in combination with a high-speed network.

The ITWM belongs to the pioneers concerning the application of PC clusters for industrial simulation problems. It is currently operating parallel systems with more than 1,000 CPUs for the development of parallel software and the solution of industrially relevant computation tasks.

Technological problems have stopped the continuous increase in performance by faster clock rates; dual core, quad core, and more are the current keywords for a furtherperformance increase. The parallelization of software has thus become a key technology in all IT relevant areas. Future efficient parallel software will have a hybrid structure, on one hand making optimum use of multicore subsystems, and on the other hand scaling over many computers.

The new Cell Processor, which has been produced in cooperation by the companies IBM, Toshiba, and Sony and is working in the new PlayStation, is a prototype of this new generation of CPUs. In a strategic cooperation with IBM's development laboratory in Böblingen, the **CC HPC** develops applications and analyzes the Cell platform with respect to its suitability as a HPC system. The IBM Cell Cluster, which has been installed at the ITWM in June 2008, made it into the Top500 with 1,120 cores and even became first place on the list of the most energy efficient systems (www.green500.org). The extension of research activities in the field of multicore systems was one of the main subjects in the year 2008. The project activities of the **CC HPC** are currently divided into four fields:

Parallelization and performance analysis – seismic

The focus of activities in 2008 lay on the cooperation with our partners IBM and StatoilHydro. By combining fundamental HPC know-how and practical knowledge, the **CC HPC** has succeeded in developing particularly high-performance codes that meet great interest among clients. The Competence Center was especially successful in 2008 in the area of seismic, with a long-term cooperation agreed upon with the Norwegian company StatoilHydro.

Grid Computing – Cloud Computing

In the year 2008, grid computing turned to cloud computing. New services such as the Amazon Elastic Compute Cloud also offered new possibilities for us to apply our technology. Our individual grid solution PHASTGrid was ported to the Amazon Cloud and was presented early as a productive platform during trade fairs and talks. We are dealing with the license management of cloud and grids on the basis of an innovative idea, currently developing a respective product.

The **CC HPC** is an active participant in D-Grid and the European EGEE project. One focus of activities is the further development of basic grid technologies and the participation in the grid standardization boards. Within a second main subject, Fraunhofer grid solutions have been further developed in cooperation with the Fraunhofer partners within the internal enterprise grid project. We have been able to apply PHASTGrid within different cooperation projects with industrial partners. A productive environment for the assessment of the quality and performance of the grid infrastructure has been made

available to the D-Grid community by the development of the grid benchmark portal *jawari.itwm.fraunhofer.de*.

Visualization

In the field of CPU-based ray tracing methods, commercial products are meanwhile available. With PreStack-Pro, we were able to present an innovative software product for the quantitative analysis and visualization of large prestacks in the oil industry at international trade fairs (SEG, EAGE). An entirely CPU-based postprocessor for the analysis of computation results of the software MAGMASOFT was developed for the company MAGMA Gießereitechnologie, and was delivered to customers.

HPC-Tools

High-performance tools for the development of HPC software and systems are GraPA, a parallelization framework for hybrid applications in the area of multicore distributed memory, FVM, a software interface providing global shared memory on Infiniband clusters for parallel applications, and the parallel Fraunhofer file system FhGFS.

The activities with respect to the development of new tools for future multicore processors have been combined within the Multicore Innovation Center, funded by the Federal Ministry of Education and Research, the Fraunhofer-Gesellschaft, IBM, and further industrial partners.

Main subjects

- service-oriented computing
- nanoscale process modeling
- parallel algorithms, performance analysis
- seismic data processing and interpretation
- Cell Competence Center
- Visualization of large amounts of data

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In September, the ITWM opened its doors for a day, combining science and culture within a multifaceted program: guided tours, lectures, software demos, Math for Kids, music, cabaret, and dramatic reading attracted hundreds of visitors to the Fraunhofer-Center. Of course, the flower arrangements were in orange – the logo color of the Scientific Year 2008.

FhGFS – the Fraunhofer Parallel File System

Due to the growing performance of modern computer architectures, the demand for more detailed analyses and simulations is also surging. However, it is not only the computational effort for the solution of the problems which is increasing; the requirements to which the underlying storage technologies are subject are growing simultaneously. Data sets of several terabytes are not uncommon today, for example in the field of seismic measurements.

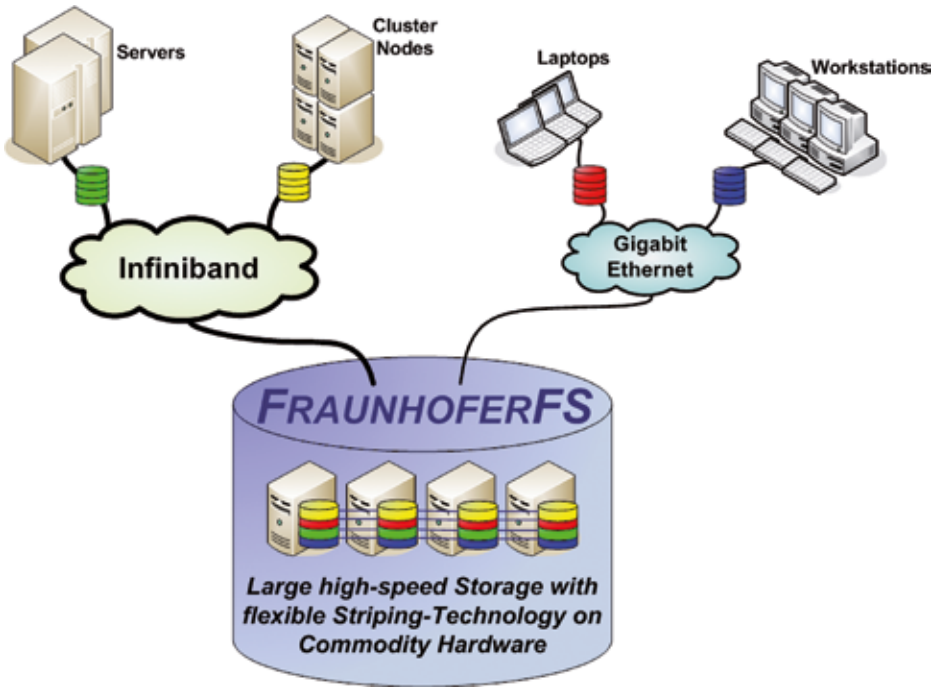
Conventional technologies, such as RAID systems, can only be scaled to a limited degree in practice; with the Fraunhofer Parallel File System, the **CC HPC** has therefore followed a similar approach as with respect to the shortening of computation time: parallelization by storage clusters. The files are stored on several servers; the data can thus be processed many times faster compared to conventional technologies.

A special property of the FhGFS is that not only the pure data contained within the files is distributed, but also the administration information (meta data) and tasks of the system. In combination with the high-performance network Infiniband, this allows for a throughput of several gigabytes per second also in the case of more complex workloads.

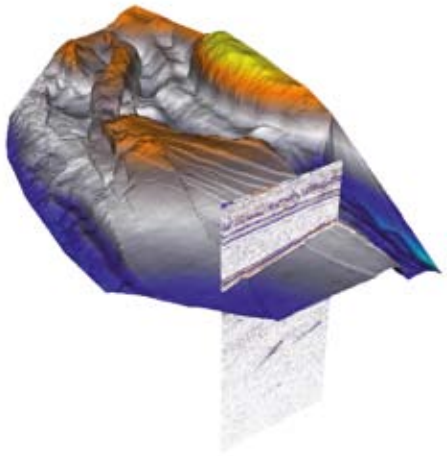
Another main focus during the development of the system – apart from easy administration – is the largest possible flexability for the user. The system does not only support a variety of different distribution patterns for the data, but also mixed cluster configurations that have become increasingly important again today, for example configurations of x86 and cell nodes. Currently, the file system is therefore also applied for the implementation of the storage system on the Fraunhofer Cell Cluster with 1,000 cores (until November 2008 first place among the Green Top 500!), providing transmission rates of more than 2GB/s.

In the past, the project already met large interest among the **HPC** community during several trade fairs; it is currently freely available for download on http://www.fhgfs.com.

Fraunhofer FS



PreStack-Pro

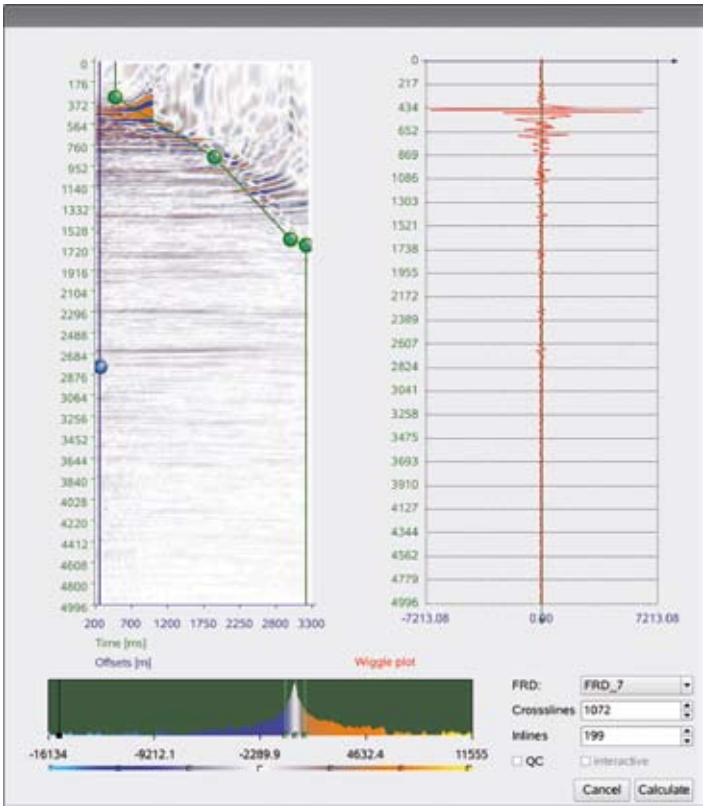


3d visualization of stack data within a seismic horizon

Seismic measurement methods – especially the seismic reflection method – are very important for the exploration of crude oil and natural gas. Artificially excited sound waves are used for the examination of the subsurface. These are excited at several different points at the surface. Measuring instruments like geophones or hydrophones are recording the movements of the soil caused by the waves at the surface. The propagation velocities of the waves and also the runtimes depend on the type of material to be penetrated. The rock-dependent sound velocities and the velocity contrasts occurring at stratum boundaries can be determined on the basis of the reflection runtimes and strengths; besides, subsurface structures can be rendered visually. However, before gaining such results we have to go through numerous processing phases of the terabyte-size data, which is very time-consuming and require considerable computing effort. Seismic processing is a time-consuming and expensive process.

The optimal parameterization during seismic processing requires active quality control in numerous steps. Different criteria such as the general character of the seismic results, amplitudes along reflectors, or disturbances must be evaluated. Stacking results and seismic results before stacking must often be represented simultaneously. All these steps of quality control require being accompanied by good visualization technologies. The visualization of large amounts of seismic data still is a very complex and expensive process in the industry today, which is however of considerable importance for the interpretation of oil and gas reservoirs.

The innovative software platform PreStack-Pro, developed at the ITWM, offers the possibility of a quantitative analysis and visualization of such large seismic data sets. In the last few years, PreStack-Pro has been further developed continuously in cooperation with our Norwegian partner ENVISION and the oil industry. An efficient rendering kernel newly developed in 2008 allows a fast interactive navigation through the data sets distributed throughout the main memory. The combination of high-performance parallel algorithms leads to shorter processing times for methods which significantly influence the productivity in seismic processing and interpretation today, having thus become a unique feature of PreStack-Pro. The Remote Viewer offers the possibility to apply the tool location-independently without significant losses in performance also in joint cooperation world-wide.



Interactive data processing with the example of stack

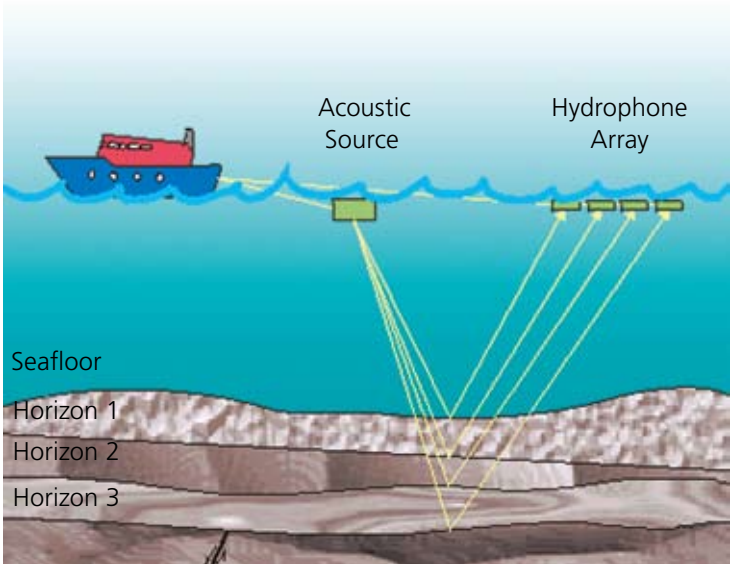
Seismic data processing and migration

The intention of the seismic reflection methods is the reconstruction of an exact representation of the subsurface, which can thus be interpreted with respect to its structure and dynamics. Due to the increasing depth and complexity of reservoirs, there is a constant high demand for improved processing methods for the large amounts of data sets occurring during the acquisition of crude oil and natural gas. The Department **HPC** combines the competence with respect to the efficient implementation of numerical algorithms by parallelization, vectorization, etc., on current and future hardware structures with the geophysical expert knowledge. In the last few years, the area of seismic processing, in particular of seismic migration, has thus become the essential application area of high performance computing in the institute.

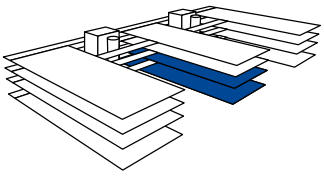
In cooperation with the oil industry, new migration methods are developed and already existing methods are accelerated essentially by new implementations on modern hardware architecture. The new development of the method of 3d-GRT migration in the angle area solves the polyvalence problem of the wave fronts in complex media, thus allowing for statements with respect to the reflection strength of subsurface layers. Direct information as to the pore contents of the rock might be gained there from. Only the institute's own concept of a virtual machine allows for the realization of such a method, because all the seismic data must be held in the main memory of the computer cluster due to the quasi-random multiple accesses to parts of the data set. This method will be presented in detail in the following project.

We were able to prove a large increase in efficiency for the Kirchhoff method by the implementation on a cell chip cluster. The experience as to the efficient programming on future multicore chip architectures, resulting there from, is helpful for the implementation with respect to wave equation based migrations which require much more computing time. The range of available seismic algorithms has been and currently is extended by research work, for example on seismic reflection tomography, radon transform for multiple suppression, and anisotropic filter processes. The application possibilities of the institute's visualization and processing/interpretation software PreStack-Pro are thus continuously extended by the implementation of these new developments.

Volume of the SEG-EAGE salt dome data set migrated by 3d-GRT



Ship equipped with hydrophones



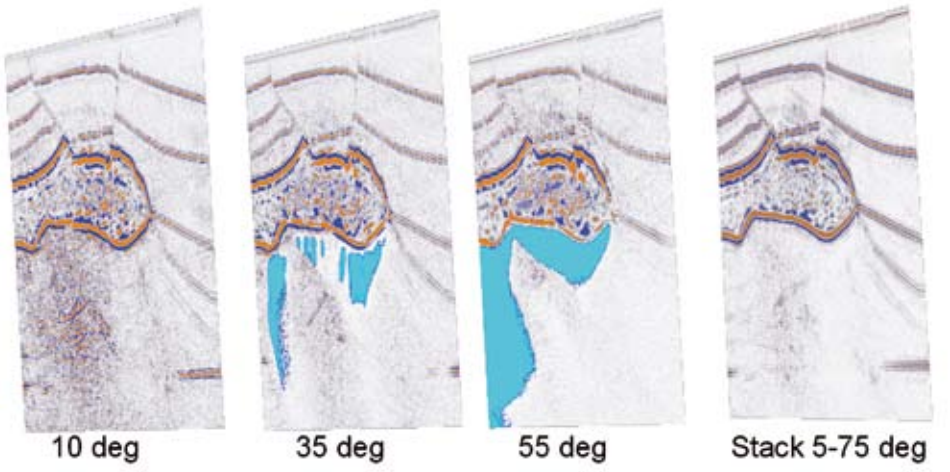
Radon-Transformation-Migration

The implementation of a new method for the prestack migration of seismic data is based on the theory of the Generalized Radon Transform (GRT). This method works without the numerous disadvantages of conventional ray-based migration methods like the Kirchhoff migration. Within a project that was initiated two years ago, we have been able to implement this method on massively parallel computer architectures by order of the company StatoilHydro. The method is now representing the only stringent application of GRT theory in three dimensions worldwide.

The special feature of the GRT migration is that the image of the subsurface is computed by the integration of the data measured at the surface over the unit sphere. The gathers required for the further interpretation being thus directly available as the migration result, dependent on the reflection angle. Besides, this type of integration solves the problems of amplitude conservation and handling of polyvalent wave fronts in complex structures of the subsurface. However, GRT does not offer the possibility of a previous sorting of the data, for example with respect to offset classes, because the contribution of seismic traces to points of the subsurface is only revealed by the ray-tracing results during the migration. In principle, each trace may contribute to every subsurface point, unfortunately in an a priori unpredictable order. As a consequence, the entire seismic prestack data set must be held in the main memory of the computer cluster.

The three-dimensional implementation of GRT is based on ten years of experience in such methods with respect to two-dimensional cases. The jump from 2d to 3d is enormous, because it is not only the data input that increases by one to two dimensions, but also the integration area by two dimensions, and the output as well by one to two dimensions.

Current results show very well the amplitude conservation of the GRT migration method and the achievable image quality, so that any further developments of 3d-GRT can now concentrate on special subsurface media (e. g., anisotropy) and on accelerating the method.



Migrated subsurface image depending on the reflection angle

Grid- und Cloud-Computing

In scientific applications, grid computing is a well-established basis for computations involving large amounts of data. Apart from the established grid technologies, cloud computing has recently become an interesting possibility for enterprises to buy computing power only if it is really needed. This main subject is focused on the use of these technologies in cooperation with interested enterprises.

Service-Oriented Computing by PHASTGrid

PHASTGrid allows for computing tasks to be distributed among arbitrary computers. The middleware is based on the SOA approach and can be integrated easily into already existing infrastructures. The service gateway accepts the compute tasks, distributing these among available computers. The decision whether a computation will be carried out in a company's own data processing center, within the grid, or on a cloud computing platform, can be taken dynamically. PHASTGrid optimizes the application.

License management by GenLM

Established software licensing methods often represent an obstacle in service-oriented computing. Existing license management methods do not offer any possibility to use a license of the user at the computing center of the service provider. Often, the service provider must be in possession of an individual license. With GenLM, the **CC HPC** is for the first time presenting a tool for software producers to enable their customers to use the licenses flexibly.

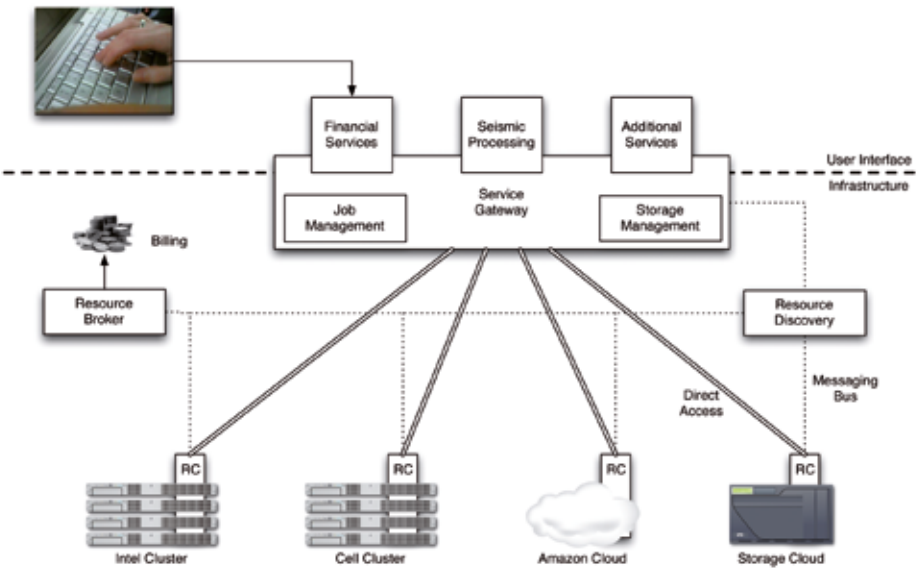
Other products

Diverse other products complete the portfolio of the **CC HPC**. Jawari is a high-performance benchmarking tool for the comparison of different grid technologies. The virtualization solution XenBEE combines the advantages of virtualized machines in a handy environment and allows for the development of private computing clouds. The Calana scheduler uses market mechanisms in order to determine the cheapest computing resources for given jobs.

Projects in the grid environment

In the last year, the Fraunhofer WISA (economically oriented strategic alliance) "Enterprise Grids" was concluded successfully: apart from the development of grid technologies for application within enterprises, the project was also focused on the consultation of companies. Within the D-Grid project "PartnerGrid", available products are further refined in cooperation with partners from research and industry.

The Fraunhofer Grid Alliance combines the competences of several Fraunhofer institutes. The resulting experience is not only applied within industrial projects, but also integrated into the standardization of protocols in the framework of the Open Grid Forum.



Different applications are bundled via the service gateway. The distribution of computing tasks to the respective optimal resources is carried out automatically by the PHASTGrid technology.

Dr. Norman Ettrich, Dr. Tiberiu Rotaru, Kai Krüger, Dr. Franz-Josef Pfreundt, Christian Mohrbacher, Sven Breuner, Dr. Martin Kühn, Dr. Dominik Michel, Maxim Ilyasov Benedikt Lehnertz, Frauke Santacruz, Alexander Petry, Dr. Hendrik Adorf, Tobias Götz, Mathias Dalheimer, Nikolai Ivlev, Ely Wagner Aguiar de Oliveira, Dr. Dimitar Stoyanov, Dr. Dirk Merten, Evgeny Ivanov

Fraunhofer-Chalmers Research Centre for Industrial Mathematics FCC

The Centre has shown an annual income level slightly below thirty million Swedish crowns or three million Euros from 2006 – 2008, each year making a positive net.

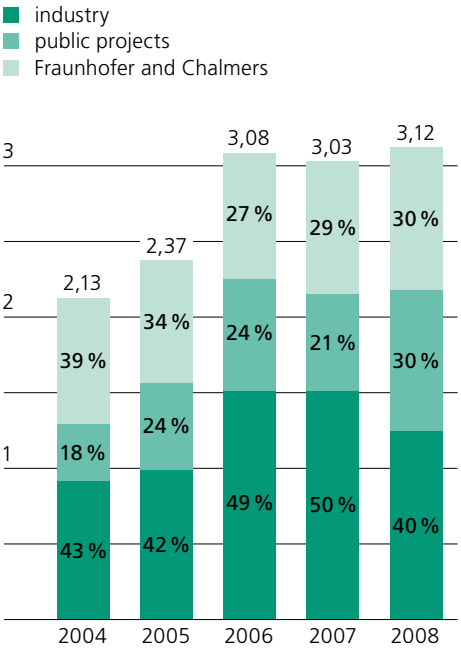
Together with our partners Chalmers and the Fraunhofer Institute of Industrial Mathematics ITWM, we cover a wide range of applications. In 2008, the project exchange reached approximately ten million Swedish crowns with each partner including basic project funding. For 2008 and 2009, we have started an industrial partner group IPG. The research theme 2008 was "Inverse problems, parameter and structure identification, and optimization". The IPG met twice in Gothenburg and twice in Kaiserslautern to define a research program on the basis of a research scenario and industrial scenarios, making a synthesis.

In order to offer an interesting option to Chalmers students and at the same time boost our base for future recruitments, the Centre made a student campaign by the end of the year. As a result we have hired twenty students for contracted work and master thesis projects.

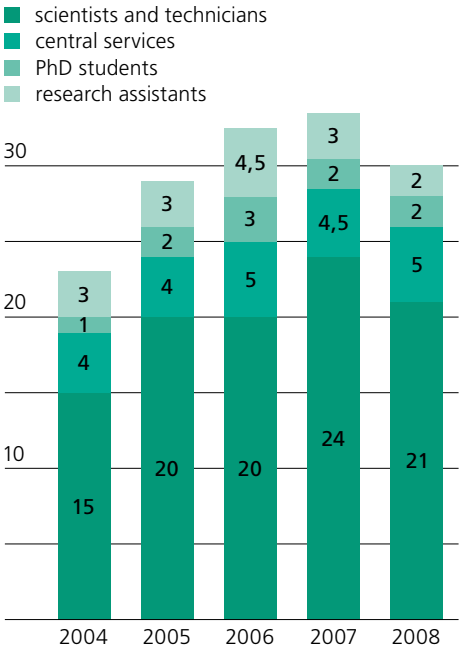
The profile of the Centre is controlled by its income structure. The result of 2008 is in line with the Fraunhofer financial model, i. e. the project volumes from industry (40%), public financiers (30%), and Fraunhofer and Chalmers (30%) are well in balance. We noted a decrease in the number of staff in 2008, which we expect to re-establish the next year. The diagrams below show the development of the Centre in terms of income and staff.

The department **Geometry and Motion Planning**, working in close cooperation with the Chalmers Wingquist Laboratory, has established an income level well above one million Euros. The activities 2008 included the start of two Vinnova MERA projects on electrocoating and efficient inspection, growing interest in path-planning software, and substantial joint development with the ITWM department **Mathematical Methods in Dynamics and Durability**.

Operating budget development in million €



Personnel development



The department **Computational Engineering and Design** has expanded its work on multi-physics applications involving fluid-structure and fluid-electromagnetics interaction, in particular through projects with Swedish and other European industrial partners together with the ITWM departments **Optimization, Transport Processes,** and **Flow and Material Simulation**. The department runs a strategic cooperation with Chalmers on simulation-based optimization through the Gothenburg Mathematical Modelling Centre GMMC.

The department **Reliability and Risk Management** has its focus on fatigue life and load analysis of mechanical structures in, e. g., automation and automotive industry. The department runs a three-year joint project with the Chalmers Stochastic Centre, Fraunhofer ITWM Dynamics and Durability, and SP Technical Research Institute of Sweden. The industrial partners are six European truck manufacturers from Germany, Italy, the Netherlands, and Sweden.

The department **Systems Biology and Bioimaging** has continued to grow by adding substantial industrial (pharmaceuticals) and public (EU and GMMC) income to our long-term grant from the Swedish Foundation for Strategic Research SSF. Our cooperation with the ITWM department **System Analysis, Prognosis, and Control** has intensified through a project on particle filtering techniques briefly described below.

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uno.navert@fcc.chalmers.se

Main subjects

- Geometry and Motion Planning
- Computational Engineering
- Risk Management
- Systems Biology and Bioimaging

Electromagnetics

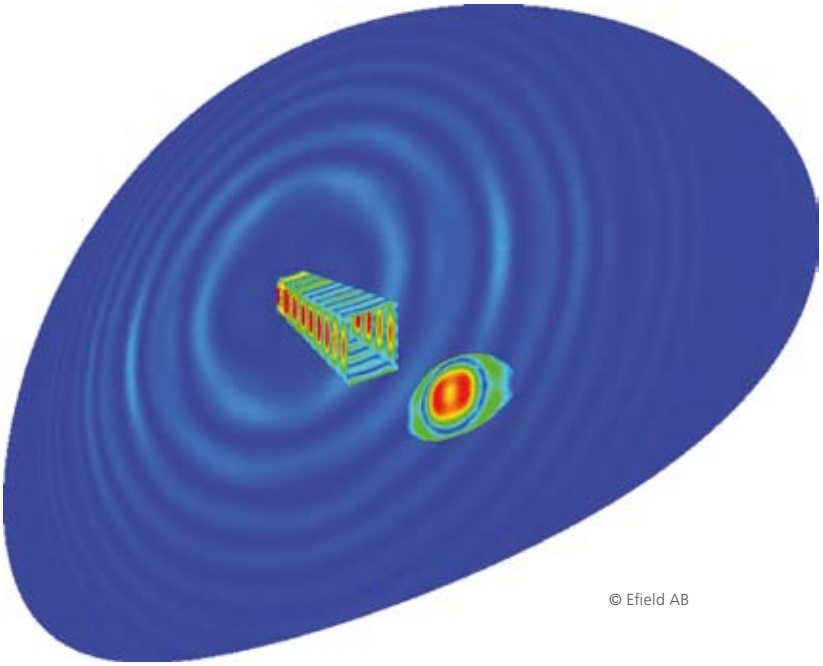
The rapid increases in computer power and the development of efficient numerical methods have facilitated the computer simulation of complex electromagnetic propagation and interaction phenomena. This is an emerging technology in application areas such as wireless technology, antenna analysis, electromagnetic compatibility, microelectronics, radar signature, and medical engineering.

The high frequency activities in electromagnetic simulations at the FCC are based on the software suite developed in the national research and software development project GEMS (General ElectroMagnetic Solvers). FCC's participation as sub-contractor in GEMS has brought the Center to the forefront in electromagnetic simulations. FCC is an implementation partner of the recently foun-ded company Efield AB that commercializes the GEMS software. FCC markets efield® to new customers and performs consultancy projects based on the software.

In 2008, the FCC group in computational electromagnetics was involved in the preparation of new releases of efield®. The final touches were also put to the research on alternative integral formulations for dielectric and lossy materials. This novel work resulted in a faster convergence of the multilevel fast multipole method (MLFMM) by orders of magnitude, compared to the original solver. Proof-of-concept projects were performed with companies on the German market interested in acquiring the software. The German Aerospace Centre (DLR) has chosen efield as its simulation tool for radar signature applications. Within GMMC, we initiated efforts on the EEG-based source localization in the human brain by using finite element methods.

The efield® software is a result of a successful collaboration between Swedish academia and industry. FCC has played an important part in the development of the software and has performed further development contracted by Efield AB. The activities during 2008 have mainly comprised preparation work for new releases and the improvement of the MLFMM solver for dielectric materials.

The software is used for antenna design, electromagnetic compatibility, and radar signature and microwave applications. The solvers are based on formulations in both time domain and frequency domain, a key feature being the use of hybrid methods. In the frequency domain, a Method of Moments (MoM) boundary integral solver is coupled to a physical optics solver; in the time domain, an unstructured finite element method is coupled to a finite difference method. The underlying idea of the hybrid methods is to take advantage of the strengths of the individual methods without suffering from their weaknesses, and thereby substantially increase the spectrum of solvable problems.

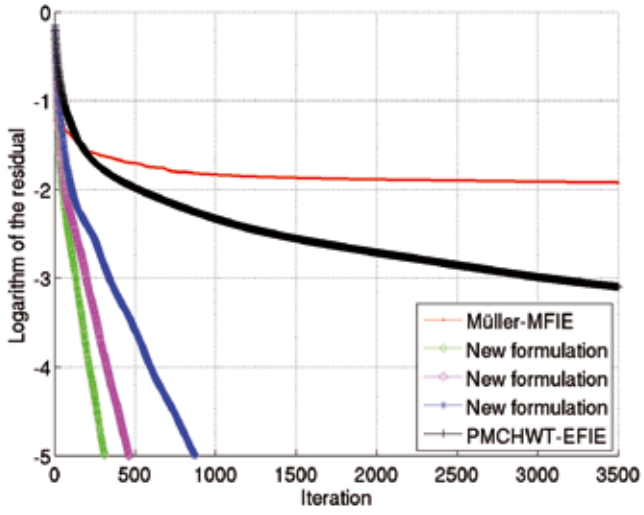


Surface currents on a horizontally polarized L-Band Cassegrain reflector antenna simulated by efield® on the basis of the multilevel fast multipole method (MLFMM) (illustration from Efield AB).

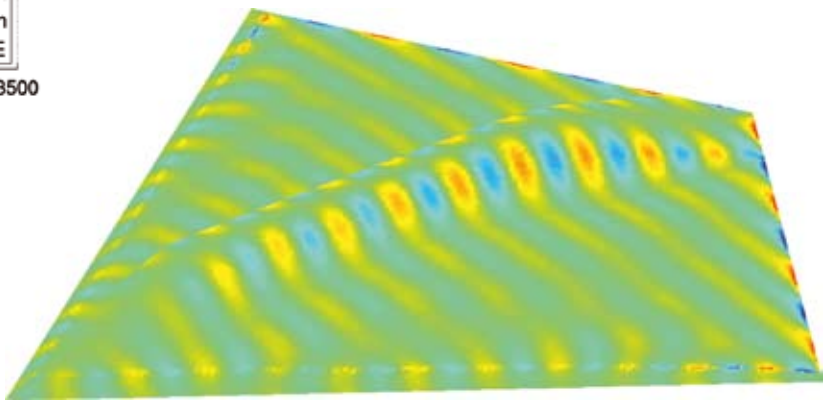
Improved integral formulations for dielectric bodies in MLFMM

In the frequency domain solver, the integral formulation for dielectrics is very ill-conditioned. This is a problem in particular when iterative methods are used, because the iterative process converges slowly if it converges at all. This fact limits the use of the fast multipole method to problems with only perfect electric conductors, which is of crucial importance. In a project earlier funded by the industrial consortium STM, alternative integral formulations have been investigated.

A particularly challenging problem is the combination of dielectric material with metal. The bistatic radar cross section for the UAV Eikon with radar absorbing material on the leading edges is presented below. Results for the old solver based on the Rumsey reaction formulation (PMCHWT) are compared to results for which the PMCHWT formulation has been combined with the Müller formulation. The old implementation suffered from a non-optimal scaling of the equations. Furthermore, a careful analysis of eigenvectors and eigenvalues lead us to a novel combination of equations in the Müller formulation. As can be seen in the figure, the effect on convergence is dramatic.



Comparison of the bistatic radar cross section for the UAV Eikon with radar absorbing material on the leading edges, computed by the two standard formulations and the new solver based on an improved integral formulation, respectively.



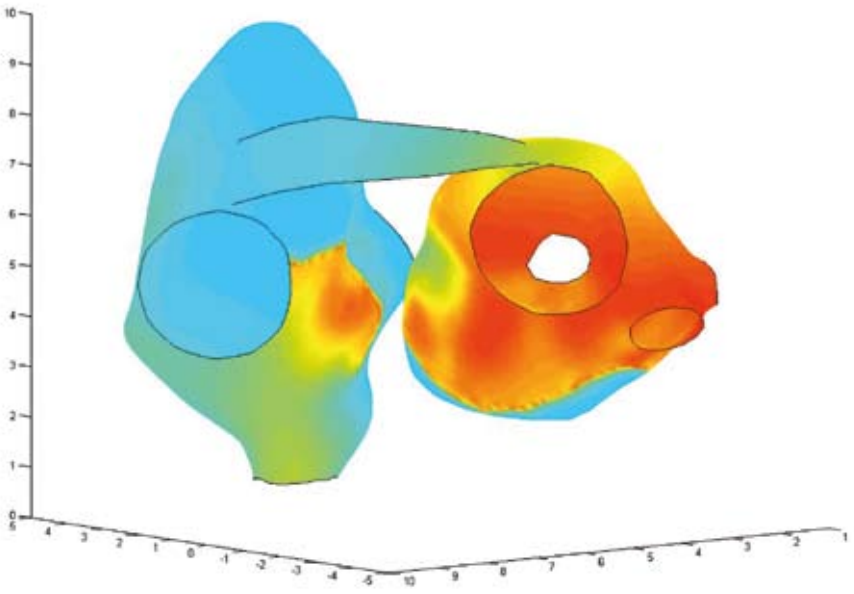
Surface currents on an Eikon, modeled as a metallic object with radar absorbing material on the leading edges, after a radar pulse has hit the aircraft. A multilevel fast multipole method (MLFMM) has been used.

In Silico Simulation of Fibrillation in Canine Atrial Tissue

Atrial fibrillation is the most common form of heart arrhythmia and is associated with a 5 – 6 fold increase in the incidence of stroke. Computer models describing the temporal evolution of the action potential over realistic atrial geometries are very useful for the understanding or prediction of the effect of drugs acting as inhibitors on single or multiple ion-channels. In particular, these models enable us to relate the dynamics of the action potential propagation to drug effects on the single cell level. This in turn permits the in silico reconstruction and investigation of phenomena like atrial flutter and fibrillation.

In this project in cooperation with AstraZeneca R&D Mölndal, we have developed a framework for the modeling and simulation of electro-chemical activity in large-scale cell networks. The simulation framework has been used to induce fibrillation and flutter like electro-dynamic activity in cell networks, and the effect of ion-channel modulation on this behavior has subsequently been investigated. The quality of the results is in good accordance with in vivo observations, which indicates that the approach is viable for this application and motivates further extensions and studies. The type of simulations presented in this work has great potential to provide insights into the underlying mechanisms of atrial fibrillation and flutter, as well as a basis for the prediction of drug effects.

Recently, the atrial geometry model has been improved by a refinement of the spatial discretization. Furthermore, detailed low-level mechanistic descriptions of a particular ion-channel including drug interaction effects have been investigated and integrated into the atrial model. The cell models used in previous projects implement ion-current mechanisms by using the Hodgkin-Huxley paradigm. In order to gain insight into the quantitative effects of a drug inhibiting a particular ion-channel, so-called Markov models are considered to provide the necessary level of detail. We have implemented more detailed models of a particularly interesting ion-channel by using this formalism. The refined cell model has been used both for single cell simulations in ring-like constructions, see figure 3, and in the full-scale atrial model providing a better approximation of the real drug-ion-channel interaction effects in terms of increased refractory period, i.e. the time until a cell can be restimulated, in order to prevent self-sustained electro-chemical behaviors.

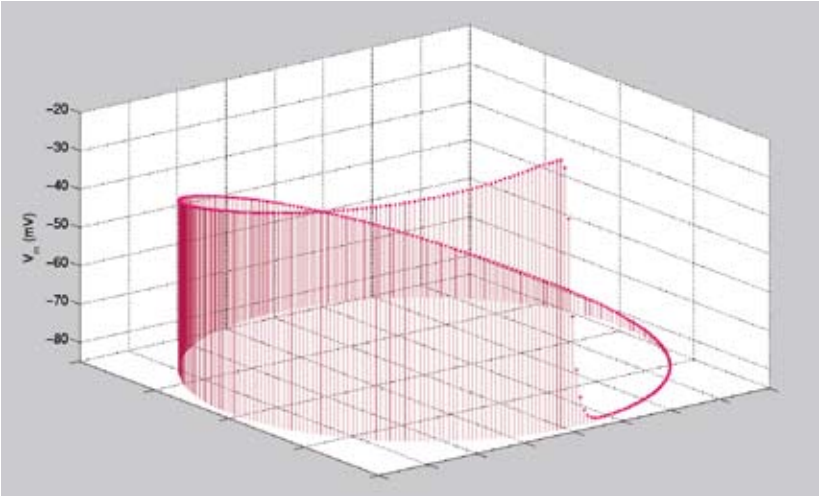


Simulated fibrillation in a canine atrial model. Left and right atrium connected by a conducting structure known as Bachmann's bundle.

Parameter Estimation by Particle Methods with Applications to Systems Biology

Particle methods, also called Sequential Monte Carlo methods, have recently evolved as a tool for the task to make inference on unknown parts of nonlinear dynamical systems. Biological systems generally show a wide range of variability involving stochastic models with non-Gaussian distributions. This makes a hard task of parameter estimation, even more so in dynamical systems with dependent observations, leading to high-dimensional likelihoods.

In a project carried out in collaboration with the ITWM, our aim was to investigate, implement, compare, and benchmark approaches for parameter estimation based on Maximum Likelihood, prediction of error minimization, and Bayesian approaches. During the course of the project, a Mathematica implementation of the investigated particle methods has been developed.



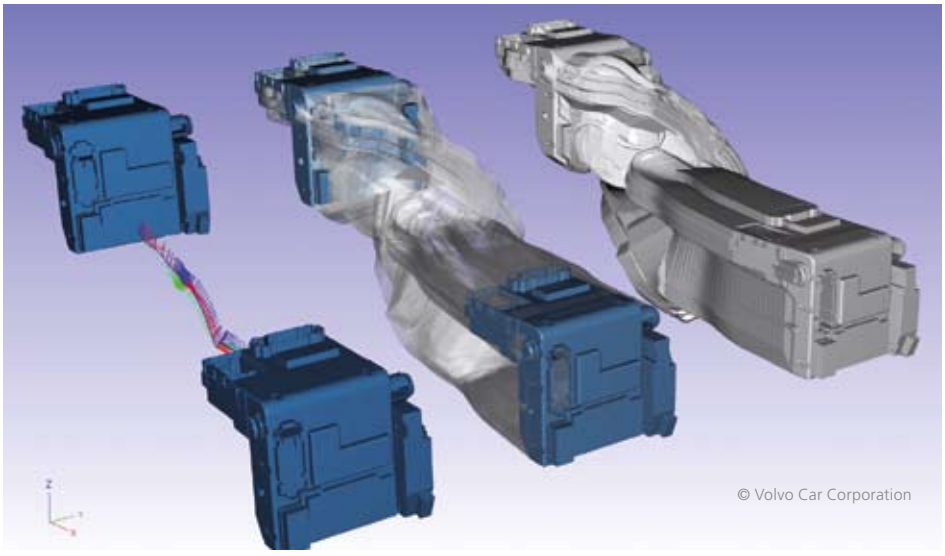
Simulated reentry in a ring of atrial myocytes. This construction can be used to investigate how the increased action potential duration on the single cell level affects the ability to trigger self-sustained oscillations in simple geometries.

Automatic Path Planning for Rigid Bodies and Industrial Robots

Although modern industries use virtual prototypes to replace physical prototypes, visualize assembly processes, and program industrial robots off-line, the full potential of the virtual factory has not been reached yet. Programming of motions and paths for robots and equipment is still done manually because the existing support for automatic path planning is very limited. Another limitation is the geometrical accuracy between the virtual model and the physical reality; geometrical tolerances must therefore be considered during path planning. This is a first step, going from nominal to production adapted virtual models and hence connecting the production loop including styling, design, and manufacturability.

Virtual verification of products which can be assembled and later on disassembled for service purposes is an important part of geometry simulation in the manufacturing industry. Methods and software for the automatic generation of collision-free assembly paths are therefore of great interest. Additionally, the off-line programming of robots and coordinate measurement machines used in the factory lead to hard problems for the simulation engineer when he/she tries to find collision-free paths between points manually, simultaneously minimizing cycle time and joint wear. Therefore, FCC operates to support the following path planning applications:

- Assembly visualization/verification/design
- Assembling with robot
- Welding and sealing
- Coordinate measurement machine
- Load balancing, sequencing and coordination of robot operations



An assembly path and corresponding swept volume

Prof. Rikard Söderberg, David Wrangborg, Björn Andersson, Dr. Mats Kvarnström, Mikael Sunnåker, Prof. Jacques de Maré, Dr. Johan Carlson, Jenny Ekenberg, Dr. Robert Bohlin, Dr. Fredrik Edelvik, Dr. Stefan Jakobsson, Mikael Wallman, Staffan Björkenstam, Dr. Marco Günther, Annika Eriksson, Dr. Robert Rundqvist, Sebastian Tafuri, Frederik Ekstedt, Tomas Hermansson, Dr. Uno Nävert, Daniel Segerdahl, Anders Ålund, Helen Johansson, Johan Torstensson, Dr. Mats Jirstrand, Prof. Igor Rychlik, Dr. Jan Hauth, Dr. Sara Lorén, Dr. Andreas Mark, Jonas Hagmar, Prof. Mats Rudemo, Deborah Korb, Dr. Pär Johannesson, Joachim Almquist, Michael Patriksson, Domenico Spensieri

Talks

Altendorf, Hellen
Morphological Analysis of 3D Random Fiber Networks
Workshop »3d Imaging, Analysis, Modeling and Simulation of Macroscopic Properties«, Kaiserslautern, November 2008

Andrä, Heiko; Steiner Konrad
Simulation in der Prozesskette Guss
2. Niederdruckguss-Kolloquium bei Kurtz, Hasloch, April 2008

Becker, Jürgen
Materialmodellierung und Auslegungssimulation für Brennstoffzellen
Woche der Technologie, Mainz, November 2008

Becker, Jürgen
Modelling of Two-Phase Behaviour in the Gas Diffusion Layer of PEFCs
5th ModVal Symposium, Winterthur (CH), March 2008

Becker, Jürgen; Schulz, Volker; Wiegmann, Andreas
Modelling of Two-Phase Behaviour in the Gas Diffusion Layer of PEFCs
ECMI, London (GB), July 2008

Berger, Martin; Schröder, Michael; Küfer, Karl-Heinz
A Constraint-based Approach for the Two-dimensional Rectangular Packing Problem with Orthogonal Orientations
International Conference Operations Research, Augsburg, September 2008

Berger, Martin; Schröder, Michael; Küfer, Karl-Heinz
A Constraint-based Optimization Approach for Placement Problems in 2.5D System in Package Electronic Design Automation
19. Internationale Wissenschaftliche Konferenz, Mittweida, November 2008

Birgersson, Fredrik; Dressler, Klaus; Baumann, Sonja; Herkt, Sabrina
Reifensimulation mit Abaqus und MKS-Modellen
Abaqus-Benutzerkonferenz, Bad Homburg, September 2008

Böhm, Martin
Image Processing Algorithms in Robotics and Automation
Dianji University, Shanghai (CN) , December 2008

Böhm, Martin
Image Processing and Applications
Universite de Savoie, Annecy (F) , May 2008

Böhm, Martin
New Technology, New Ideology - Innovation of High-Level Applied Talents Cultivation Model
Int. Symp. of High Education, Shanghai (CN), October 2008

Dalheimer, Mathias
Financial Computing on Cell
IBM-Accenture Workshop, Montpellier (F), 2008

Dalheimer, Mathias
Lizenzmanagement für Grids und Clouds
1. D-Grid Lizenzmanagement-Workshop, Hannover, November 2008

Dalheimer, Mathias
Service oriented Computing
Abschlussveranstaltung Enterprise Grids, Stuttgart, October 2008

de Oliveira, Ely
Jawari – A Grid Benchmarking and Monitoring Service for Grid Assessment
Federal University of Campina Grande (BR), February 2008

de Oliveira, Ely
Jawari – A tool for Quality of Service Assurance in Grid Infrastructures
4th D-Grid Monitoring Workshop, Hannover, November 2008

Desmettre, Sascha; Gould, John; Szimayer, Alexander
Own-Company Stockholding and Work Effort Preferences of an Unconstrained Executive
First European Summer School in Mathematical Finance, Paris (F), September 2008

Kehrwald, Dirk; Latz, Arnulf; Latta, Daniel; Schönfeld, Friedhelm
Holistic simulation of dielectrophoretic traps
ICMMES 2008, Amsterdam (NL), June 2008

Dreßler, Klaus
Ermittlung invarianter Anregungen zur Simulation von Nutzfahrzeugmodulen
3. Grazer Nutzfahrzeugworkshop, Graz (A), May 2008

Dreßler, Klaus; Speckert, Michael; Müller, Roland; Weber, Christof
Customer Loads Correlation in Truck Engineering
FISITA 2008, The Future of Automobiles and Mobility, München, September 2008

Erlwein, Christina
Asset allocation under a multi-dimensional HMM setting
Fifth World Congress of the Bachelier Finance Society, London (GB), July 2008

Erlwein, Christina
Scenario generation for a portfolio optimisation problem within an HMM framework
International conference on applied mathematical programming and modelling APMOD, Bratislava (SK), May 2008

Ettrich, Norman; Merten, Dirk; Foss, Stig-Kyrre
True-amplitude angle migration in complex media
EAGE, Rom (I), June 2008

Ettrich, Norman
Detailgenaue Modellierung urbaner Oberflächen zur Koppelung von Kanalnetz- und Oberflächenabflusssimulation
Öffentliche Abschlussveranstaltung 3ZM-Grimex, Dresden, November 2008

Ewe, Hendrik; Klein, Peter; Pieper, Martin
Heat Conductivity in Sintered Aluminium Fibers
Cellular Metals for Structural and Functional Applications 2008, Dresden, October 2008

Ewing, Richard; Iliev, Oleg; Lazarov, Raytcho; Rybak, Iryna; Willems, Jörg
An Efficient Approach for Upscaling Properties of Composite Materials with High Contrast of Coefficients
Jerusalem (IL), January 2008

Godehardt, Michael
MAVI – modulares System für die Analyse von Volumenbildern
Workshop »Computertomografie und Analyseverfahren für industrielle Anwendungen«, Kaiserslautern, March 2008

Godehardt, Michael
MAVI: Geometrische Charakterisierung von Objekten und Komponenten in Volumenbildern
Control 2008, Stuttgart, April 2008

Günther, Marco
Simulation based flow optimization for polymer melts
INDEX08, Genf (CH), April 2008

Hering-Bertram, Martin
Geometric data representations for simulation and visualization
Dagstuhl Seminar on Geometric Modeling, Dagstuhl, May 2008

Hering-Bertram, Martin
Sound tracing: rendering listener specific acoustic room properties
Eurovis 2008, Eindhoven (NL), May 2008

Hietel, Dietmar
Mathematics is technology – industrial applications of maths
University of Canterbury, Christchurch (NZ), April 2008

Hietel, Dietmar
Mathematik ist Technology – Angewandte Mathematik für die Industrie
Tag der Mathematik, Universität Kassel, February 2008

Hietel, Dietmar
Modeling and simulation for innovation
Polyamide & Intermediates Conference, Düsseldorf, October 2008

Hietel, Dietmar
Modeling and simulation of nonwoven processes
Nonwoven Research Academy, Chemnitz, October 2008

Hietel, Dietmar

Modelling and simulation of fiber dynamics in turbulent flow

Mechanical Enginering Seminar, Christchurch (NZ), March 2008

Hietel, Dietmar

Modelling and simulation of nonwoven processes

INDEX08, Genf (CH), April 2008

Hietel, Dietmar

Technologiesprung durch Simulation von Fadendynamiken

Hofer Vliesstofftage, Hof, November 2008

Iliev, Oleg

On modeling and simulation of certain industrial flow problems

Berlin, June 2008

Iliev, Oleg

On modeling and simulation of coupled flows in plain and in porous media

Berlin, June 2008

Iliev, Oleg; Ewing, Richard; Lazarov, Raytcho; Willems, Jörg

On an upscaling approach for calculating effective properties of insulation materials

London (GB), July 2008

Iliev, Oleg; Ewing, Richard; Lazarov, Raytcho; Willems, Jörg

On upscaling heat conductivity for a class of industrial problems

18th International Conference on Domain Decomposition Methods, Jerusalem (IL), January 2008

Iliev, Oleg; Lakdawala, Zahra; Ciegis, Raimondas; Starikovicius, Vadimas; Dedering, Michael; Stausberg, Wolfgang

On new challenges for CFD simulation in filtration

Leipzig, April 2008

Iliev, Oleg; Lakdawala, Zahra; Latz, Arnulf; Steiner, Konrad; Wiegmann, Andreas; Willems, Jörg; Popov, Peter; Roesch, Katja; Rybak, Iryna; Starikovicius, Vadimas

On Theory and Praxis of the Calculation of Effective Conductivity and of the Permeability of Porous Materials

Kaiserslautern, November 2008

Iliev, Oleg; Lakdawala, Zahra; Willems, Jörg; Starikovicius, Vadimas; Popv, Peter

On a numerical upscaling approach for solving Stokes and Stokes-Brinkman problems

Bad Herrenalb, October 2008

Iliev, Oleg; Lakdawala, Zahra; Willems, Jörg; Starikovicius, Vadimas; Popv, Peter

On numerical upscaling for Stokes and Stokes-Brinkman flows

Dubrovnik (HR), October 2008

Iliev, Oleg; Latz, Arnulf; Rybak, Iryna; Shklyar, Inga; Willems, Jörg

Fast calculation of effective thermal conductivity of insulation materials

Kaiserslautern, September 2008

Iliev, Oleg; Steiner, Konrad

Flow and material simulation

Utrecht (NL), April 2008

Jegorovs, Jevgenijs

Wave based method in a complex domain: accuracy improvement

ISMA2008, Leuven (B), September 2008

Jung, Dominik

Physikalische Modellierung der Luftbalgfederung eines Sattelaufliegers

DNT-Workshop, Kaiserslautern, October 2008

Jung, Dominik; Speckert, Michael; Dressler, Klaus

Modellierung und Simulation eines neuen Prüfstandkonzepts zur Achserprobung

4. ASIM-Workshop, Wismar, May 2008

Junglewitz, Andreas; Spies, Martin; Rieder, Hans

Operational Challenges: Extension of Propeller Welding Repairs for a Higher Availability of Ships

The Marine Propulsion Conference, London (GB), March 2008

Kabel, Matthias; Andrä, Heiko

Werkstoffauslegung von Dämmstoffen und Isolationsmaterialien

Tag der Technologie 2008 »Werkstoffe und Energie«, Mainz, November 2008

Klein, Peter

A framework for concurrency in numerical simulations using lock free data structures: The Graph Parallel Architecture -GraPA

International Conference on Parallel and Distributed Computing, Applications and Technologies, Dunedin (NZ), December 2008

Kohl, Matthias; Ruckdeschel, Peter

R-Packages for Robust Asymptotic Statistics

useR, Dortmund, August 2008

Korn, Ralf

Are Modern Portfolio Optimization Methods really applicable ?

METU Ankara (TR), April 2008 & Jahrestagung DGVFM, Dresden, April 2008

Korn, Ralf

Besser länger leben mit Mathematik

Tag der offenen Tür, ITWM, September 2008 und Kreissparkasse Kaiserslautern, December 2008

Korn, Ralf

CPDOs: Modelling and Optimal Leverage Function

RICAM-Workshop »Special Semester on stochastics with emphasis to finance«, Linz (A), September 2008

Korn, Ralf

Faszination Finanzmathematik – Forschung und Anwendung in Theorie und Praxis

Martin Luther Universität, Halle, November 2008

Korn, Ralf

Finance at Fraunhofer

Launch der Cambridge-Kaiserslautern Finance Alliance, London (GB), June 2008

Korn, Ralf

Finanzmathematik und die Bankenkrise- Schuldig oder nicht schuldig

Fraunhofer ITWM Kaiserslautern, November 2008

Korn, Ralf

Langlebigkeit – Finanz- und versicherungsmathematische Hintergründe

Qx-Club, Wiesbaden, March 2008

Korn, Ralf

Mathematisches Modellieren als Technologie

Kickoff der Forschungsinitiative Zukunft, TU Kaiserslautern, November 2008

Korn, Ralf

Modernes Management finanzieller Risiken (Workshop mit 5 Vorträgen)

R&V-Versicherung, Wiesbaden, June 2008

Korn, Ralf

Optimal Portfolios with transaction costs – a practical approach

University of Cambridge (GB), February 2008

Korn, Ralf

Optimal Portfolios: Basic Methods in the Continuous-time Setting

University of St. Andrews (GB), November 2008

Korn, Ralf

Optimal Portfolios: New Variations of an Old Theme

University of St. Andrews (GB), November 2008

Korn, Ralf

Worst-Case Control for Optimal Portfolios: Introduction and recent Aspects

Workshop on Finance, Stochastics, and Insurance, Bonn, February 2008

Korn, Ralf

Worst-case portfolio optimization with applications to finance and insurance

University of Amsterdam (NL), November 2008 und Heriot-Watt-University Edinburgh (GB), November 2008

Korn, Ralf

Worst-Case Portfolio-Optimierung: Überblick und neue Resultate

Universität Saarbrücken, January 2008

Korn, Ralf; Korn, Elke

The Simulation tool box for the financial engineer (Workshop mit 17 Vorträgen)

METU Ankara (TR), April 2008

Kreier, Peter; Schwendimann, Michael; Rieder, Hans

Adaptive Ultraschallprüfung aus dem Block gewalzter Stahlknüppel

DACH-Tagung 2008, St. Gallen (CH), April 2008

Kroisandt, Gerald

ALM bei einem schwedischen Rentenfonds

DAA-Workshop für junge Mathematiker, Reisensburg, September 2008

Küfer, Karl-Heinz

Interactive Decision Support

Konferenz für Angewandte Optimierung in der virtuellen Produktentwicklung, Universität Karlsruhe, June 2008

Küfer, Karl-Heinz

Mathematik – Motor der Wirtschaft

19. Internationale Wissenschaftliche Konferenz, Mittweida, November 2008 (plenary address)

Kuhnert, Jörg

Finite Pointset Method (FPM) for free surface and multiphase flows. Industrial applications.

6th International Conference on Computational Fluid Dynamics in the Oil & Gas, Metallurgical and Process Industries CFD 2008, Trondheim (N), June 2008

Kuhnert, Jörg

FPM applications to coupled production processes in glass forming

Glass Trends 2008, TNO Eindhoven (NL), November 2008

Kuhnert, Jörg

Meshfree flow solver (FPM) applied to formation of chill ripples in glass forming processes

9th ESG conference, Trencin (SK), June 2008

Lakdawala, Zahra

Coupling multiscale simulations for filtration processes

Zürich (CH), November 2008

Lakdawala, Zahra; Iliev, Oleg; Wiegmann, Andreas; Rief, Stefan

Coupling Micro-and Macro Simulation for Filtration Processes

Leipzig, April 2008

Lang, Holger; Dreßler, Klaus

An improved multiaxial stress-strain correction model for elastic FE postprocessing

6th international conference on low cycle fatigue (LCF6), Berlin, September 2008

Lang, Patrick

Das Methoden-Cockpit: Eine integrierte Plattform zur systematischen Technologieentwicklung

Forum »Fokus Technologie«, Stuttgart, October 2008

Latz, Arnulf

Schüttgutsimulation - Der aktuelle Stand der Forschung und die Bedeutung für die Industrie

17. Schüttguttag, Wiesbaden, June 2008

Latz, Arnulf

Simulation der Aerosoldynamik in komplexen Strukturen mit Anwendungen auf die menschliche Lunge

MEF Tag 2008, München, June 2008

Latz, Arnulf; Schmidt, Sebastian

A unified hydrodynamic model for dilute and dense granular flow

Frühjahrstagung der Deutschen Physikalischen Gesellschaft, Berlin, February 2008

Lautensack, Claudia

Analyse und Modellierung von Mikrostrukturen

Institut für Technische Mechanik, Universität Karlsruhe (TH), January 2008

Lautensack, Claudia

Anisotropy analysis of 3d point processes

Stochastiktage, Aachen, März 2008 & Workshop »Random Models in Science, Engineering and Medicine«, Smögen (S), August 2008

Lautensack, Claudia

Charakterisierung der Mikrostruktur von Faserwerkstoffen

Industrielle CT-Tagung, Wels (A), February 2008

Lautensack, Claudia

Image Analysis for Applications in Paper Industry

Fraunhofer-Chalmers Centre, Göteborg (S), February 2008

Lautensack, Claudia

Modelling of cellular structures using locally adaptable morphology

SSIAB 08, Toulouse (F), May 2008

Lautensack, Claudia

Modelling of foam structures using locally adaptable morphology

3D IMS 2008, Carcans-Maubuisson (F), September 2008

Lautensack, Claudia

Poisson Laguerre Tessellations

ISVD 2008, Kiew (UA), September 2008

Lefteriu, Sanda

A new approach to modeling multi-port scattering parameters

7th International Conference on Scientific Computing in Electrical Engineering, Helsinki (FIN), October 2008 and Workshop on Model Reduction for Circuit Simulation, Hamburg, October 2008

Lefteriu, Sanda

System identification from frequency domain

3th Smart Structures Workshop, Leuven (B), October 2008

Linn, Joachim

Discrete rods from geometric finite differences

Seminar »Discrete Differential Geometry«, DFG research unit »Polyhedral Surfaces«, TU Berlin, February 2008

Linn, Joachim; Lang, Holger

Quasistatic and dynamic simulation of dicrete Kirchhoff and Cosserat rods

Kolloquium über numerische und angewandte Mathematik, Universität Göttingen, October 2008

Maag, Volker; Küfer, Karl-Heinz

Optimal Cooling in Injection Molding

Opteng 2008, Rio de Janeiro (BR), June 2008

Maasland, Mark

Oberflächenprüfung und –charakterisierung von Werkstoffen mittels Bildverarbeitung

Tag der Technologie 2008, Mainz, November 2008

Maasland, Mark; Teutsch, Christian

Kombinierte optische Vermessung und Oberflächenprüfung von 3D-Objekten

Fraunhofer-Vision Seminar »Inspektion und Charakterisierung von Oberflächen mit Bildverarbeitung«, Karlsruhe, December 2008

Marburger, Jan

Space mapping and optimal shape design

GAMM 2008, Bremen, April 2008

Mohring, Jan

Integrated Multi-Field Simulation, Model Reduction, and Model Based Controller Design

Smart Structures Basic Course, Budapest (H), February 2008

Mohring, Jan

On the way to a parametric reduced model of the LMS concrete car

3th Smart Structures Workshop, Leuven (B), October 2008

Mohring, Jan

Parametric reduced models of smart structures

Smart Structures Workshop, Leuven (B), December 2008

Müller, Marlene

Calibrating and Validating Credit Rating Systems (Workshop mit 4 Vorträgen)

FIRN Workshop, Sydney (AUS), October 2008

Müller, Marlene

Nonparametric Components in Discrete Choice Models (with an Application to Credit Scoring)

Monash University, Melbourne (AUS), October 2008; National University of Singapore, Singapur (SGP), November 2008

Müller, Marlene

Redesigning Ratings: Assessing the Discriminatory Power of Credit Scores under Censoring

Edith Cowan University, Perth (AUS), October 2008; University of Technology, Sydney (AUS), October 2008

Müller, Marlene
Statistics of Credit Risk
Summer School des Zentrums für Statistik (ZfS) der Universität Göttingen, Hann.Münden, May 2008

Neunzert, Helmut
Denn das Schöne ist nichts als des Schrecklichen Anfang.
Tage des Schmuck-Designs, FH Idar-Oberstein, May 2008

Neunzert, Helmut
Marcello Anile – the driving force for the cooperation
Memorial Marcello Anile, Catania (I), April 2008

Neunzert, Helmut
Mathematik – Motor der Innovation
Kolloquium Universität Konstanz, May 2008

Neunzert, Helmut
Mathematik für den Alltag – keine alltägliche Mathematik
Österreichische Akademie der Wissenschaften, Radon-Lecture, Wien (A), April 2008

Neunzert, Helmut
Mathematik für den Alltag –meist keine alltägliche Mathematik
Tag der Technomathematik, Universität Hamburg, April 2008

Neunzert, Helmut
Mathematik für die Industrie
Symposium »Wirtschaft trifft Mathematik«, Paderborn, November 2008

Neunzert, Helmut
Mathematik ist Technologie – wissen das auch Schüler?
Technotag an der TU Kaiserslautern, May 2008

Neunzert, Helmut
Mathematik und die Innovationskraft unserer Wirtschaft
Ringvorlesung »Mathematik + X« der Universität des Saarlandes, Saarbrücken, December 2008

Neunzert, Helmut
Mathematische Modellierung in der Schule
Schulen der Stadt Wien, Wien (A), April 2008

Neunzert, Helmut
Produktionsfaktor Mathematik
Podiumsdiskussion Berlin, November 2008

Neunzert, Helmut; Siedow, Norbert
Mathematic in Schools: Inverse Problems
Stella Maris College, Chennai (IND), November 2008

Nickel, Stefan
A Territory Design Problem Arising in the Context of the WEEE-Directive
Rotterdam (NL), October 2008

Nickel, Stefan
Discrete Ordered Median Problems: Models, Solution Techniques and Extensions
Saint-Maxime La Baume (F), August 2008

Nickel, Stefan
Hospital Logistics
Nantes (F), March 2008

Nickel, Stefan
Location Planning using Geographic and Demographic Data
Santa Barbara, Calif. (USA), June 2008; Augsburg, September 2008

Nickel, Stefan
Location Problems in Supply Chain Management
Vila Real (P), March 2008

Nickel, Stefan
The Maximal Dispersion Territory Design Problem
Madrid (E), June 2008

Nickel, Stefan
WEEE and Max Dispersion Territory Design Problems
Washington, DC (USA), October 2008

Niedziela, Dariusz; Latz, Arnulf
Modeling and simulation of particle concentrations in powder injection molding
Workshop on simulation of powder injection molding process - progress and expectations by industry, Besancon (F), November 2008

Niedziela, Dariusz; Latz, Arnulf
Numerical Simulations of Sand-Air Mixtures for the Casting Industry
8th World Congress on Computational Mechanics (WCCM8); 5th European Congress on Computational Metchods in Applied Science and Engineering (ECCOMAS 2008), Venice (I), June-July 2008

Nögel, Ulrich
Credit Derivatives and CDOs
4 Vorträge; FIRN Workshop, Sydney (AUS), August 2008

Nögel, Ulrich
Option Pricing in Local and Stochastic Volatility Models
University of Technology, Sydney (AUS), August 2008; Edith Cowan University, Perth (AUS), August 2008

Nögel, Ulrich
Option Pricing in Local and Stochastic Volatility Models (Workshop mit Doppelvortrag)
Australian National Univ., Canberra (AUS), August 2008

Nowak, Uwe; Berger, Martin; Schröder, Michael; Stroe, Bogdan; Fionik, Eugenia; Küfer, Karl-Heinz
Multiobjective Simulated Annealing with Adaptive Objective-Driven Neighborhoods for 2.5D System-in-Package Design
International Conference Operations Research, Augsburg, September 2008

Öngün, Yekta; Bartel, Dirk; Deters, Ludger
Ein hydrodynamisches Interface Element zur FE-Berechnung der Mischreibung an Elastomerdichtungen
20. Deutschsprachige Abaqus-Benutzerkonferenz, Bad Homburg, September 2008

Pfreundt, Franz-Josef
High Performance Computing at the Fraunhofer ITWM
ASIM Workshop, Erlangen, February 2008

Pfreundt, Franz-Josef
Is HPC going green?
ISC Dresden, June 2008

Pfreundt, Franz-Josef
Service-oriented Computing
IT-Virtualisierung, Frankfurt, February 2008

Pfreundt, Franz-Josef
Service-oriented Computing für die Finance and Exploration - Erwartungen für die nächsten Jahre
RWE-Innovation-Workshop, Herten-Westerhold, April 2008

Pfreundt, Franz-Josef
The big switch
Forum Virtualisierung Grid, Stuttgart, May 2008

Pfreundt, Franz-Josef; Ettrich, Norman; Merten, Dirk; Shea, Bill; Foss, Stig-Kyre; Rhodes, Mark; Osen, Are
HPC-Solution for Angle domain depth migration and pre-stack visualization.
Vortrag SEG Konferenz, Las Vegas (USA), November 2008

Pieper, Martin
Mathematics is a Technology: Applied Research for Industry at Fraunhofer ITWM
Universität Göttingen, November 2008

Raillon, Raphaele; Mahaut, Steve; Leymarie, Nicolas; Lonné, Sébastien; Spies, Martin
Results of the 2008 UT Modeling Benchmark Obtained with Two Semi-Analytical Models: Responses of Flat-bottom Holes Under Surfaces of Different Curvatures
35th Annual Review of Progress in QNDE 2008, Chicago (USA), July 2008

Redenbach, Claudia
3D-Charakterisierung und Modellierung von Schäumen
DGM-Arbeitskreis »Quantitative 3D-Mikroskopie«, Kaiserslautern, November 2008

Redenbach, Claudia
Realistic Models for Open Foams
Workshop »3d Imaging, Analysis, Modeling and Simulation of Macroscopic Properties«, Kaiserslautern, November 2008

Redenbach, Claudia
Zufällige Laguerre-Mosaike
AG Stochastik, TU Kaiserslautern, December 2008

Redenbach, Claudia; Sych, Tetiana; Schladitz, Katja; Godehardt, Michael; Wirjadi, Oliver; Spies, Martin
3D Characterisation and Modelling of Foam Structures
International Symposium on NDT in Aerospace, Fürth, December 2008

Redenbach, Thomas
Mathematik in industriellen Anwendungen
MINT-Camp, Wiesbaden, February 2008

Rief, Stefan; Schmidt, Kilian; Wiegmann, Andreas
Simulation of Ceramic DPF Media, Soot Deposition and Pressure Drop Evolution Using GeoDict
World Filtration Congress 2008, Leipzig, April 2008

Rief, Stefan; Wiegmann, Andreas
Simulation von Filtermedien mit GeoDict
STFI Chemnitz, March 2008

Rösch, Ronald
Bildverarbeitung am Fraunhofer ITWM
DGM-Arbeitskreis »Quantitative 3D-Mikroskopie«, Kaiserslautern, November 2008

Rösch, Ronald
Fehlerdetektion in texturierten Oberflächen im praktischen Einsatz
Fraunhofer Vision Technologietag, Magdeburg, October 2008

Rösch, Ronald
Typischer Aufbau eines Online-Oberflächeninspektionssystems
Fraunhofer-Vision Seminar »Inspektion und Charakterisierung von Oberflächen mit Bildverarbeitung« Karlsruhe, December 2008

Rösch, Ronald; Meyer, Fernand
Digital Engineering – Virtual Design of Materials
Carnot-Fraunhofer-Workshop, Strasbourg (F), January 2008

Ruckdeschel, Peter; Kohl, Matthias
distrMod – an S4-class based package for statistical models
useR, Dortmund, August 2008

Scheben, Rolf; Götz, Siegbert; Spies, Martin; Rieder, Hans
Verbesserte Qualitätssicherung durch das Zusammenspiel von Inspektionsprozeduren mit Simulations- und Rekonstruktionsalgorithmen
DACH-Tagung 2008, St. Gallen (CH), April 2008

Scherrer, Alexander
Multi-criteria optimization in IMRT planning: From a theoretical concept to a clinical software tool
Symposium on Radiobiologically based optimization for IMRT, Göteborg (S), September 2008

Schladitz, Katja
Analyse und geometrische Modellierung der Mikrostruktur poröser Werkstoffe
Workshop »Dämmstoffe und Isolationsmaterialien - Design und Charakterisierung«, Kaiserslautern, September 2008

Schladitz, Katja
Analyse von Volumenbildern mit MAVI
Fraunhofer Vision Technologietag, Magdeburg, October 2008

Schladitz, Katja
Geometric characterisation of pore space in volume images
IEEE NSS/MIC 2008 Conference, Dresden, October 2008

Schladitz, Katja
Geometrische Charakterisierung von Objekten und Komponenten in Volumenbildern
Workshop »Computertomografie und Analyseverfahren für industrielle Anwendungen«, Kaiserslautern, March 2008

Schladitz, Katja
Integral geometric and morphological methods for 3d image analysis
Materials Science and Engineering, Nürnberg, September 2008

Schmidt, Oliver
Coupling of numerical and symbolic MOR techniques
Workshop »Model Reduction for Circuit Simulation«, Hamburg, October 2008

Schmidt, Sebastian; Latz, Arnulf; Niedziela, Darek
Simulation granularer Strömungen in industriellen Anwendungen
NAFEMS 5th Anniversary CFD-Seminar Simulation komplexter Strömungsvorgänge (CFD) - Anwendungen und Trends, Wiesbaden, March 2008

Schröder, Michael
Forschungsprojekt VerSiPlektor - Optimieren von Bauteilplatzierungen in 3D
16. FED-Konferenz Fachverband Elektronik Design, Bamberg, September 2008

Schröder, Michael
Industrial Mathematics: Lessons from the last mile
Expertenseminar »Mathematik in Theorie und Praxis«, Universität Göttingen, July 2008

Schröder, Michael
Versiplektor: Entwurf und Optimierung – Ein Autoplacer für vertikale Systems-in-Package
Fachgremium Mikrotechnische Produktion, Nürnberg, June 2008

Schröder, Michael; Schüle, Ingmar
Interaktive mehrkriterielle Optimierung für die regionale Fahrplanabstimmung in Verkehrsverbünden
HEUREKA 08, Stuttgart, March 2008

Schüle, Ingmar
Fahrplansynchronisierung im ÖPNV
TU Clausthal, January 2008

Schüle, Ingmar
Mathematiker im Beruf
Universität Göttingen, December 2008

Schüle, Ingmar; Dragan, Anca; Radev, Alexander; Schröder, Michael; Küfer, Karl-Heinz
Multicriteria optimization for regional timetable synchronization in public transport
Operations Research 08, Augsburg, September 2008

Seelig, Thomas; Latz, Arnulf; Sanwald, Sven
Werkstoffmodellierung und Crash-Simulation bei langfaserverstärkten Thermoplasten
Kunststofftagung Fellbach, June 2008

Serna, Ivan
Approximating the Nondominated Set in Convex Multicriteria Optimization
GOR-AG Entscheidungstheorie und Praxis, Wittenberg, March 2008

Siedow, Norbert
Direkte und inverse Temperaturbestimmung in semitransparenten Materialien
Universität Kassel, FB Mathematik, Kassel, April 2008

Siedow, Norbert
Ein neuartiges Verfahren zur hochpräzisen Auslegung von Freiformlinsen
Fraunhofer-Challange Meeting, München, September 2008

Siedow, Norbert
Energieeffiziente Produktion von Glas
Tag der Technologie, Mainz, November 2008

Siedow, Norbert
Inverse and parameter identification problems
Industrial Partner Group, Göteborg (S), February 2008

Siedow, Norbert
Mathematik kann hören
Rotariertreffen am ITWM, Kaiserslautern, August 2008; Tag der offenen Tür, Kaiserslautern, September 2008

Siedow, Norbert
Mathematische Modellierung
MNU-Workshop, Kaiserslautern, May 2008

Siedow, Norbert
Pharmakokinetik im Innenohr
ITWM-Seminar, Kaiserslautern, December 2008

Siedow, Norbert
Radiative Heat Transfer and Applications for Glass Production Processes
CIME - Summerschool, Montecatini (I), October 2008

Siedow, Norbert

Temperatursimulationen und thermische Spannungen im Glas

DGG Fachausschusssitzung IV »Glasmaschinentechnik und Formgebung«, Würzburg, March 2008

Spangl, Bernhard; Ruckdeschel, Peter; Dutter, Rudolf

Approximate Conditional-mean Type Filtering for State-space Models

useR, Dortmund, August 2008

Speckert, Michael

Erfassung und Modellierung der Betriebsbeanspruchung als zentrales Element der Auslegung

1. Konferenz Digitale Nutzfahrzeugtechnologie, Fraunhoferzentrum Kaiserslautern, October 2008

Speckert, Michael

Statistische Methoden in der Betriebslastenermittlung von Fahrzeugen und der Auswertung von Lebensdauerversuchen

OTTI-Fachforum Systemzuverlässigkeit von Elektronikbauteilen, Regensburg, May 2008

Spies, Martin

Advanced Ultrasonic NDT of Aero Engine Components Using Validated Simulation Techniques

International Symposium on NDT in Aerospace, Fürth, December 2008

Spies, Martin

Der Einsatz von Ultraschall zur Materialprüfung - Einführung in die Thematik

15. Workshop »Physikalische Akustik« der Deutschen Gesellschaft für Akustik gemeinsam mit der Deutschen Physikalischen Gesellschaft, Bad Honnef, October 2008

Spies, Martin

Erhöhte Anforderungen an die Qualitätssicherung moderner Werkstoffe und Bauteile - Aktuelle Trends in der Ultraschall-zfP

9. PQMT Kolloquium, Robert Bosch GmbH, Gerlingen, January 2008

Spies, Martin

Simulation und Validierung der Charakterisierung poröser Werkstoffe mittels Ultraschall

Workshop »Dämmstoffe und Isolationsmaterialien - Design und Charakterisierung«, Kaiserslautern, September 2008

Spies, Martin

Simulation-Based Ultrasonic Inspection of Metallic and Non-Metallic Components

4th IPG-Workshop, Kaiserslautern, October 2008

Spies, Martin

Validierung semi-analytischer Simulation der Fehlerprüfung an ebenen und gekrümmten Bauteilen anhand des internationalen UT Benchmarks 2007

DACH-Tagung 2008, St. Gallen (CH), April 2008

Spies, Martin; Andrä, Heiko; Rieder, Hans; Schulz, Volker; Zemitis, Aivars

Charakterisierung und Optimierung von Dämmstoffen durch die Kombination von zfP-Verfahren und Werkstoffsimulation

DACH-Tagung 2008, St. Gallen (CH), April 2008

Spies, Martin; Rieder, Hans

Quantitative Fehlercharakterisierung aus Ultraschall-HF-Daten mittels simulationsgestützter Auswerteverfahren

DACH-Tagung 2008, St. Gallen (CH), April 2008

Steiner, Konrad

Integration von Werkstoffmodellierung und Prozesssimulation bei der virtuellen Produktauslegung

Cluster-Forum: Simulation in der Werkstofftechnik, Nürnberg, May 2008

Steiner, Konrad

Simulation von Materialeigenschaften

Workshop: Computertomographie und Analyseverfahren für industrielle Anwendungen, Saarbrücken & Kaiserslautern, March 2008

Steiner, Konrad

Virtuelles Materialdesign – Methoden und Anwendungen

Werkstofftage Mainz, November 2008

Steiner, Konrad

Virtuelles Materialdesign für Dämmstoffe und Isolationsmaterialien

Workshop: Dämmstoffe und Isolationsmaterialien – Design und Charakterisierung, Kaiserslautern, September 2008

Steiner, Konrad; Andrä, Heiko

Robuste, gussgerechte Designoptimierung von Aluminium-Bauteilen durch Sensitivitätsanalyse und Kontrolle von Gefügedefekten

Clustertreffen: Prozesskette Guss, Ingolstadt, November 2008

Steiner, Konrad; Hartwig, Thomas; Kraft, Torsten; Latz, Arnulf; Mortiz, Tassilo

Pulverspritzgusssimulation

NUSIM-Jahrestreffen, Bremen, January 2008

Stoev, Julian

Model reduction approaches for MIMO systems

3th Smart Structures Workshop, Leuven (B), October 2008

Strautins, Uldis; Latz, Arnulf

A mesoscale based model for concentrated fibre suspension flows

Kääriku (EST), June 2008

Sych, Tetyana; Rösch, Ronald; Schnell, Jürgen; Ackermann, Florian

Statistical analysis of fiber distribution in UHPC

UHPC Symposium, Kassel, March 2008

Velásquez, Rafael

Planungsunterstützung im OP-Management: Die Online-Planung

Städt. Kliniken Frankfurt am Main – Höchst, February 2008

Weyh, Thorsten; Linn, Joachim

Kostenersparnis bei der Produktentwicklung mithilfe des Fraunhofer-Instituts für Techno- und Wirtschaftsmathematik

SRP Seminar mit dem BVMW, Weilerbach, December 2008

Wiegmann, Andreas

Air filtration simulation with focus on slip effects

Valley Forge, Pennsylvania (USA), May 2008

Wiegmann, Andreas

An FFT-based Stokes Solver for Virtual Material Design

Fountainebleau (F), June 2008

Wiegmann, Andreas

Die Explicit Jump Immersed Interface Method und industrielle Anwendungen

Uni Bremen, March 2008

Wiegmann, Andreas

Filtration Simulation with GeoDict and FilterDict

Saclay (F), June 2008

Wiegmann, Andreas

GeoDict – von der Struktur zur Eigenschaft

Kaiserslautern, March 2008

Wiegmann, Andreas

Simulation Studies of deposition mechanisms for aerosol particles in fibrous filters including slip flow

Leipzig, April 2008

Wiegmann, Andreas

Voxel based Material Models and Material Property Computations

Stuttgart, December 2008

Winterfeld, Anton

An interior-point method for general semi-infinite programming

Universität Karlsruhe, January 2008

Winterfeld, Anton

Large-scale semi-infinite optimization applied to industrial gemstone cutting

SIMAI 2008, Rom (I), September 2008

Wirjadi, Oliver

Linear filters for computing the 3d fiber orientation in fiber-reinforced polymers

Workshop »3d Imaging, Analysis, Modeling and Simulation of Macroscopic Properties«, Kaiserslautern, November 2008

Teaching Activities

Wirjadi, Oliver

Linear filters for computing the 3d fiber orientation in fiber-reinforced polymers

DGM-Arbeitskreis »Quantitative 3D-Mikroskopie«, Kaiserslautern, November 2008

Wirjadi, Oliver

Segmentierung von Bildobjekten und -komponenten

Workshop »Computertomografie und Analyseverfahren für industrielle Anwendungen«, Kaiserslautern, March 2008

Wirjadi, Oliver; Malten, Rebekka; Godehardt, Michael; Sych, Tetiana; Schladitz, Katja; Redenbach, Claudia; Spies, Martin

3D Characterisation and Modelling of Fibrous Materials

International Symposium on NDT in Aerospace, Fürth, December 2008

Zemitis, Aivars

Elastic properties of fiber-reinforced plastics

2nd International Fraunhofer Workshop »3D Imaging, Analysis, Modelling and Simulation of Macroscopic Properties«, Kaiserslautern, November 2008

Böhm, Martin

Professur für Robotik und Bilderkennung

Fachhochschule Kaiserslautern

Dalheimer, Mathias

Grid Computing

TU Kaiserslautern, Winter term 2007/2008

Günther, Marco

Mathematik und Statistik

Fachhochschule Wiesbaden, Winter term 2008/2009

Hering-Bertram, Martin

Computer Animation

TU Kaiserslautern, Winter term 2007/2008, Winter term 2008/2009

Hering-Bertram, Martin

Visualization and VR

TU Kaiserslautern, Summer term 2008

Hietel, Dietmar

Theoretical Fluid Mechanics

University of Canterbury (NZ), 2008

Iliev, Oleg

Intensive course (7 lectures) on modeling and simulation of multiscale problems

IIT Madras (IND), November 2008

Iliev, Oleg

Modern iterative methods

TU-Kaiserslautern, Dept. of Mathematics
Winter term 2007/2008

Kehrwald, Dirk

Thermo- und Fluiddynamik.

Hochschule Mannheim, Winter term 2007/2008, Summer term 2008

Klar, Axel

Professur für Technomathematik

TU Kaiserslautern, Dept. of Mathematics

Küfer, Karl-Heinz

Applied Optimization (Oberseminar)

TU Kaiserslautern, Summer term 2008

Küfer, Karl-Heinz

Industrial Applications of Optimization (Seminar)

TU Kaiserslautern, Summer term 2008

Küfer, Karl-Heinz

Theorie von Scheduling Problemen (lectures & Übungen)

TU Kaiserslautern, Summer term 2008

Latz, Arnulf

Theorie der Kolloide und Suspensionen

TU Kaiserslautern, Summer term 2008

Müller, Marlene

Non- and Semiparametric Modelling

Humboldt-Universität zu Berlin, Winter term 2008/2009

Müller, Marlene

Statistical Aspects of Credit Rating

Humboldt-Universität zu Berlin, Winter term 2007/2008

Müller, Marlene

Statistik für Finanzdienstleister – Grundlagen

Hochschule der Sparkassen-Finanzgruppe, Summer term 2008

Neunzert, Helmut; Klar, Axel; Lang, Holger; Linn, Joachim; Siedow, Norbert

Industrial Mathematics (10 Vorlesungen)

Chennai (IND), November 2008

Nickel, Stefan

Professur für Operations Research und Logistik

Universität des Saarlandes, Saarbrücken

Prätzel-Wolters, Dieter

Professur für Technomathematik

TU Kaiserslautern, Dept. of Mathematics

Rieder, Hans

Simulation and Hardware Implementations of Digital Algorithms and Systems (Part: Implementations of Signal Processing Algorithms based on embedded DSP Technology)

HTW Hochschule für Technik und Wirtschaft des Saarlandes, Labor für Hochfrequenztechnik, Winter term 2007/2008

Publications

Amirbekyan, Abel; Michel, Volker
Splines on the three-dimensional ball and their application to seismic body wave tomography
Inverse Problems, Volume 24, Issue 1, pp. 015022 (2008).doi:10.1088/0266-5611/24/1/015022

Amirbekyan, Abel; Michel, Volker; Simons, F. J.
Parametrizing surface wave tomographic models with harmonic spherical splines
Geoph. J. Int., 2008, 174 (2), 617-628, doi:10.1111/j.1365-246X.2008.03809.x

Andrä, Heiko; Battiato, S.; Bilotta, G.; Farinella, G. M.; Impoco, G.; Orlik, J.; Russo, G.; Zemitis, A.
Structural Simulation of a Bone-Prosthesis System of the Knee Joint
Sensors 2008, 8, 5897-5926, DOI: 10.3390/s8095897(2008)

Andrä, Heiko; Gluchshenko, Olga; Ivanov, Evgeny; Kudryavtsev, Alexey
Automatic Parallel Generation of Tetrahedral Grids by Using a Domain Decomposition Approach
Comp. Math. and Math. Phys., Vol. 48, No. 8, pp. 1367-1375, (2008)

Attarakih, Menwer; Zaidan, Dia; Drumm, Christian; Tiwari, Sudarshan; Kuhnert, Jörg; Bart, Hans-Jörg
Dynamic modelling of liquid extraction columns using the Direct Primary and Secondary Particle Method (DPSPM)
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Soulie, Frederic; Siedow, Norbert; Anton, John; Lochegnies, Dominique
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Spies, Martin
Advanced Ultrasonic NDT of Aero Engine Components Using Validated Simulation Techniques
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Spies, Martin
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Spies, Martin; Andrä, Heiko; Rieder, Hans; Schulz, Volker; Zemitis, Aivars
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Süss, Philipp; Kuefer, Karl-Heinz
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Taeubner, Kai
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Velásquez, Rafael; Melo, Teresa; Küfer, Karl-Heinz
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Velichko, A.; Holzapfel, C.; Siefers, A.; Schladitz, K.; Mücklich, F.;
Unambiguous classification of complex microstructures by their three-dimensional parameters applied to graphite in cast iron
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Wahl, Reiner; Spies, Martin; Diebels, Stefan
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Wiegmann, Andreas; Schmidt, Kilian; Rief, Stefan; Cheng, Liping; Latz, Arnulf
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Winterfeld, Anton
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Wirjadi, Oliver; Malten, Rebekka; Godehardt, M.; Sych, Tetiana; Schladitz, Katja; Redenbach, C.; Spies, Martin
3D Characterisation and Modelling of Fibrous Materials
DGZfP Proceedings BB 114 Inernational Symposium on NDT in Aerospace), 331 (2008)

Scientific Graduation Theses

Ament, Corinna
Zeitdiskretes Handeln in zeitstetigen Marktmodellen
Diploma thesis, TU Kaiserslautern, Dept. of Mathematics

Andrä, Janine
Das SABR-Modell
Diploma thesis, TU Kaiserslautern, Dept. of Mathematics

Bakadir, Said
Optimales Investment bei Lebensversicherern: Anwendung von Konfidenzbändern für die Kundenentwicklung
Diploma thesis, Universität Ulm, Dept. of Mathematics

Baydar, Evren
Portfolio Optimization and Calibration with Credit Risk
Doctoral thesis, TU Kaiserslautern, Dept. of Mathematics

Becker, Jennifer
Optimierung der An- und Ablieferprozesse für Ein- und Mehrweg-Verpackungen und deren Umsetzung am Beispiel eines Automobilzulieferers
Diploma thesis, Universität des Saarlandes, Dept. of Economics

Bellmann, Jens
Visualization of acoustic simulation data by generalized photorealistic rendering
Diploma thesis, TU Kaiserslautern, Dept. of Computer Science

Breuner, Sven
Design und Entwicklung eines Konzepts für verteilte Metadaten in parallelen Dateisystemen
Master thesis, TU Kaiserslautern, Dept. of Computer Science

Daniela Dobreva
Modellierung des Verschleißverhaltens von Baumaschinen
Diploma thesis, TU Kaiserslautern, Dept. of Mathematics

de Vries, Aino
Offline Verkehrszeichenerkennung für Geoinformationssysteme
Diploma thesis, FH Oldenburg, Ostfriesland, Wilhelmshaven, Dept. of Technology

Djokic, Valentina
Simulation computertomographischer Artefakte zur Validierung von Bildanalyseverfahren
Diploma thesis, TFH Berlin, Dept. II

Ehrlich, Thomas
Verbesserung des Terminvergabeprozesses in der Radiologie des Universitätsklinikums des Saarlandes
Diploma thesis, Universität des Saarlandes, Dept. of Economics

Fionik, Eugenia
A Non-Standard Placement Problem
Diploma thesis, TU Kaiserslautern, Dept. of Mathematics

Flores, Hector
Modelling and Multicriteria Optimization of the Web Formation in a Spunbond Process
Doctoral thesis, TU Kaiserslautern, Dept. of Mathematics

Fritz, Vitali
Stockwerkübergreifende Materialflussoptimierung unter Einsatz eines automatisierten Liftsystems als Pufferlager
Diploma thesis, Universität des Saarlandes, Dept. of Economics

Gelareh, Shahin
Hub Location Models in Public Transport Planning
Doctoral thesis, TU Kaiserslautern, Dept. of Mathematics

Hancke, Phillip
Interpolationsmethoden für mehraxiale Schraubenbeanspruchungen
Student research project, Institut für Werkstoffkunde, Dept. of Mechanical Engineering, TU Darmstadt

Hauth, Jan
Grey-Box Modelling for Nonlinear Systems
Doctoral thesis, TU Kaiserslautern, Dept. of Mathematics

Hentges, Christian
Optimale Zwischenlagerung des Vormaterials für das Walzwerk der Dillinger Hüttenwerke
Diploma thesis, Universität des Saarlandes, Dept. of Economics

Herkt, Sabrina
Model Reduction of Nonlinear Problems in Structural Mechanics: Towards a Finite Element Tyre Model for Multibody Simulation
Doctoral thesis, TU Kaiserslautern, Dept. of Mathematics

Horbenko, Nataliya
Rates of Convergence to the Extreme Value
Master thesis, TU Kaiserslautern, Dept. of Mathematics

Hristova, Maria Ognianova
Global Constraints and Scheduling: Effective Propagation of the Unary Ressource Constraint
Master thesis, TU Kaiserslautern, Dept. of Mathematics

Ivanov, Evgeny
Parallel Tetrahedral Mesh Generation Based on A-priori Domain Decomposition
Doctoral thesis, TU Kaiserslautern, Dept. of Mathematics

Kessler, Christoph
Simplifizierung polygonaler Oberflächen
Diploma thesis, FH-SWF Iserlohn, Dept. of Mechanical Engineering

Klein, Carolin
Konsequenzen der Verlegung des Order-Penetration-Points in Bezug auf Lagergröße und Produktionsplanung
Diploma thesis, Universität des Saarlandes, Dept. of Economics

Klein, Thilo
Microfinance 2.0 - Group Formation & Repayment Performance in Online Lending Platforms
Diploma thesis, Universität Jena, School of Economics & Business Administration

Kotava, Natallia
High Performance Image Compression for Remote Visualization
Master thesis, TU Kaiserslautern, Dept. of Computer Science

Kratt, Karin
Navigation of Dose-Volume in Multi-Criteria Intensity-Modulated Radiotherapy (IMRT) Planning
Diploma thesis, TU Kaiserslautern, Dept. of Mathematics

Kraus, Kirstin
Klinische Pfade – Logistische Integration der Termin- und Kapazitätsplanung
Diploma thesis, Universität des Saarlandes, Dept. of Economics

Kraus, Tobias
Logistische Konsequenzen einer Verschiebung des Order Penetration Points am Beispiel eines mittelständischen Unternehmens
Diploma thesis, Universität des Saarlandes, Dept. of Economics

Krebs, Jochen
Modelle und Lösungsverfahren zur robusten Standortplanung
Diploma thesis, Universität des Saarlandes, Dept. of Economics

Krüger, Jens Thomas
Multicore Technology Requirements of Seismic Algorithm studied in the context of the Cell Broadband Engine
Master thesis, Heinrich-Heine Universität Düsseldorf

Kumar, Kundan
On computational analysis of multiphase flow in PEM Fuel Cell
Diploma thesis, TU Kaiserslautern, Dept. of Mathematics

Langenfeld, Andrea
Standortübergreifendes Bestandsmanagement in einem global agierenden Unternehmen
Diploma thesis, Universität des Saarlandes, Dept. of Economics

Liebel, Cornelia
Datenbasierte Bestimmung des optimalen Order Penetration Points in einem mittelständischen Produktionsunternehmen
Diploma thesis, Universität des Saarlandes, Dept. of Economics

Lorenz, Franz
Simulation von Lévy-Prozessen
Diploma thesis, TU Kaiserslautern, Dept. of Mathematics

Ludes, Tobias
Inverse convex Approximation of Irregular Solids by Tensor-Product Splines
Diploma thesis, TU Kaiserslautern, Dept. of Mathematics

Malysheva, Olga
Optimal Approximations of nonlinear gemstone-models by parameterized polyhedra
Master thesis, TU Kaiserslautern, Dept. of Mathematics

Meckum, Frank
Dynamische Lastverteilungskomponente zur Echtzeitauswertung von Sensordaten eines Multi-Sensoren-Systems
Diploma thesis, Berufsakademie Mannheim, Dept. of Computer Science

Michel, Frank
Simulation and visualization of in- and outdoor sound
Doctoral thesis, TU Kaiserslautern, Dept. of Computern Science

Mohrbacher, Christian
Konzeption und Implementierung einer Monitoring-Lösung für das Fraunhofer Parallel File System
Diploma thesis, Berufsakademie Karlsruhe, Dept. of Applied Computer Science

Muntz, Sabine
On The interaction of fluid with deformable porous media
Doctoral thesis, TU Kaiserslautern, Dept. of Mathematics

Obermaier, Harald
Feature based visualization of gridless vector fields
Diploma thesis, TU Kaiserslautern, Dept. of Computer Science

Orlova, Ekaterina
Estimation of Liquidity-Adjusted VaR from Historical Data
Master thesis, Humboldt-Universität zu Berlin, School of Business & Economics

Özgür Karayalcin
Design of Experiments for Truck Load Measurements
Diploma thesis, TU Kaiserslautern, Dept. of Mathematics

Radev, Alexander
Timetable Synchronization in Public Transport: Modeling Planner Preferences and Optimization with Multiobjective Evolutionary Algorithms
Master thesis, TU Kaiserslautern, Dept. of Mathematics

Sayer, Tilman
Bewertung von Mitarbeiteraktienoptionen im Hestonmodell
Diploma thesis, TU Kaiserslautern, Dept. of Mathematics

Schäfer, Isa
Logistische Aspekte des Home Health Care
Diploma thesis, Universität des Saarlandes, Dept. of Economics

Schmeißer, Andre
Geometrische Kontaktdetektion und -modellierung zur Simulation von Fadendynamiken
Diploma thesis, TU Kaiserslautern, Dept. of Mathematics

Schöneberger, Manuel
Entwicklung eines Hard-Core-Zylinder-Prozesses zur Modellierung von Fasersystemen in 3D
Diploma thesis, FH Kaiserslautern, FB Angewandte Ingenieurwissenschaften

Schwager, Jessica
Fast and Constructive Heuristics for the 2.5D Placing Problem for System im Package Design
Diploma thesis, TU Kaiserslautern, Dept. of Mathematics

Serna, Jorge Ivan
Approximating the Nondominated Set of R+ convex Bodies
Master thesis, TU Kaiserslautern, Dept. of Mathematics

Shrestha, Samir
Aerodynamic force on a fiber
Master thesis, TU Kaiserslautern, Dept. of Mathematics

Sirin, Oguz
Automatisiertes GUI-Testen
Diploma thesis, Berufsakademie Mannheim, Dept. of Computer Science

Steeg, Jörg
Mathematical Models and Algorithms for Home Health Care Services
Doctoral thesis, TU Kaiserslautern, Dept. of Mathematics

Strauch, Daniel
Konfiguration eines Grid-Netzwerkes mittels multikriterieller Methoden
Diploma thesis, Universität des Saarlandes, Dept. of Economics

Strautins, Uldis
Flow-driven orientation dynamics in two classes of fibre suspensions
Doctoral thesis, TU Kaiserslautern, Dept. of Mathematics

Süß, Philipp
A primal-dual barrier algorithm for the IMRT planning problem – An application of optimization-driven adaptive discretization
Doctoral thesis, TU Kaiserslautern, Dept. of Mathematics

Suthep, Pattama
Thailand als Beschaffungsmarkt für die Europäische Nahrungsmittelindustrie – SCM-Aspekte
Diploma thesis, Universität des Saarlandes, Dept. of Economic Science

Teichmann, Emanuel
Efficient Structural Update for Three-Dimensional Problems Using Level Set Functions
Doctoral thesis, TU Kaiserslautern, Dept. of Mathematics

Tse, Oliver
Coordinate free description of diffusion models for the inner ear
Master thesis, TU Kaiserslautern, Dept. of Mathematics

Vaikuntam, Ashok Kumar
Numerical estimate of surface parameters by Level Set Method
Doctoral thesis, TU Kaiserslautern, Dept. of Mathematics

Velásquez, Rafael
Hierarchical multi-criteria operating theatre scheduling
Doctoral thesis, TU Kaiserslautern, Dept. of Mathematics

Velten, Sebastian
Discrete Location Problems with Flexible Objectives
Doctoral thesis, Universität des Saarlandes, Dept. of Economic Science

Zhang, Aihua
Stochastic Optimization in Finance and Life Insurance: Applications of the Martingale Method
Doctoral thesis, TU Kaiserslautern, Dept. of Mathematics

Zhang, Yingping
Kalibrierung von Ausfallwahrscheinlichkeiten bei geringen Ausfallraten
Diploma thesis, TU Kaiserslautern, Dept. of Mathematics

Zherdyev, Kostyantyn
Analyse und Verbesserungspotentiale der innerbetrieblichen Logistikplanung am Beispiel der DC Truck Group im Werk Wörth
Diploma thesis, Universität des Saarlandes, Dept. of Economic Science

Zhumanbayev, Bekzhan
Performance Measures for Funds
Diploma thesis, TU Kaiserslautern, Dept. of Mathematics

Participation on Fairs and Conferences

3d-Imaging of Materials and Systems 2008
Carcans-Maubuisson (F), September 2008

Abaqus Benutzer Konferenz 2008
Bad Homburg, September 2008, Exhibitor

Analog'08 : Entwicklung von Analogschaltungen mit CAE-Methoden (GMM/ITG-Fachtagung)
Siegen, April 2008, Exhibitor

35th Annual Review of Progress in QNDE 2008
Chicago (USA), July 2008

Automatica
München, June 2008

BD Pathway User Meeting
Mannheim, April 2008

BVM 2008 (Bildverarbeitung für die Medizin)
Berlin, April 2008

CeBIT
Hannover, März 2008, Co-Exhibitor at IBM-Stand

Cellmet 2008
Dresden, October 2008

COMPOSITES EUROPE 2008
Essen, September 2008, Exhibitor

CONTROL 2008
Stuttgart, April 2008, Exhibitor

DACH-Jahrestagung 2008
St. Gallen (CH), April 2008

Design, Automation and Test in Europe
München, March 2008, Exhibitor

DVM Tagung »Optimierungspotenziale in der Betriebsfestigkeit«
Sindelfingen, October 2008, Exhibitor

DVM-Workshop: Prüfmethodik für Betriebsfestigkeitsversuche in der Fahrzeugindustrie
Dresden, January 2008, Exhibitor

EAGE 2008
Rom (I), June 2008, Exhibitor

Erfassung, Modellierung, Verarbeitung und Auswertung von 3D-Daten (Anwendungsbezogener Workshop)
Berlin, December 2008

FILTREX 2008
Köln, October 2008, Exhibitor & lectures

FISITA World Automotive Congress 2008
München, September 2008, Exhibitor

Fraunhofer Vision Technologietag
Magdeburg, October 2008

Fraunhofer-Symposium »Future Security«
Karlsruhe, September 2008

Fraunhofer-Innovationsforum »Fokus Technologie«
Stuttgart, October 2008, Exhibitor & lectures

7th French-Danish Workshop on Spatial Statistics and Image Analysis in Biology
Toulouse (F), May 2008

German Open Conference on Probability and Statistics, Stochastiktage 2008
Aachen, March 2008

36. Heidelberger Bildverarbeitungs-Forum »Fortschritte in der Bildanalyse – was benötigen die Applikationen, was bringt die Forschung?«
Heidelberg, March 2008

37. Heidelberger Bildverarbeitungs-Forum »3-D-Bildaufnahme und -analyse«
Waldkirch i. Br., July 2008

38. Heidelberger Bildverarbeitungs-Forum »Mensch und Bildverarbeitung«
Heidelberg, October 2008

HEUREKA ´08
Stuttgart, March 2008, Exhibitor & lectures

23. Hofer-Vliesstofftage
Hof, November 2008, Exhibitor

IEEE NSS/MIC 2008 Conference
Dresden, October 2008

Index 08
Genf (CH), April 2008, Exhibitor

Industrielle Computertomographie-Tagung
Wels (A), February 2008

6. International Conference on Low Cycle Fatigue
Berlin, September 2008

International Symposium on NDT in Aerospace
Fürth, December 2008

5th International Symposium on Voronoi Diagrams in Science and Engineering 2008
Kiew (UA), September 2008

ISC'08
Dresden, June 2008, Exhibitor

Jahrestagung 2008 des Commercial Vehicle Cluster (CVC)
Wörth, November 2008, Exhibitor

Launch der Cambridge-Kaiserslautern Finance Alliance
London (GB), July 2008

Materials Science and Engineering
Nürnberg, September 2008

Medizin Innovativ 2008
Nürnberg, July 2008, Exhibitor

Modeling and Validation
Winterthur (CH), March 2008

MOTEK 2008
Stuttgart, September 2008

MS Wissenschaft im »Jahr der Mathematik«
Touring exhibition, May-September 2008

mtex – Internationale Fachmesse & Symposium für Textilien und Verbundstoffe im Fahrzeugbau
Chemnitz, June 2008, Exhibitor

Olympus HCS-Meeting
Karlsruhe, March 2008

OTTI-Fachforum Systemzuverlässigkeit von Elektronikbauteilen
Regensburg, May 2008

ProcessNet
Karlsruhe, October 2008

Qualipro
Dortmund, September 2008

Regionalkonferenz der Initiative »Gesundheitswirtschaft Rheinland-Pfalz«
Kaiserslautern, January 2008, Exhibitor

Schüttguttag
Wiesbaden, June 2008

Screen Amsterdam 2008
Amsterdam (NL), September 2008, Exhibitor

SEG Annual Meeting 2008
Las Vegas, Nevada (USA), November 2008, Exhibitor

Smögen Workshop »Random Models in Science, Engineering and Medicine«
Smögen (S), August 2008

SPS/Drives/IPC 2008
Nürnberg, November 2008

Supercomputing SC2008
Austin, Texas (USA), November 2008, Exhibitor

Symposium »Textile Filter«
Chemnitz, March 2008, Exhibitor

Own Events

Tage der Technologie 2008: Werkstoffe für unser Leben
Mainz, November 2008, Exhibitor

The Marine Propulsion Conference
London (GB), March 2008

VDI Getriebe
Friedrichshafen, June 2008

VDI SIMVEC Berechnung und Simulation im Fahrzeugbau 2008
Baden-Baden, November 2008, Exhibitor

VISION 2008
Stuttgart, November 2008, Exhibitor

Workshop »Detektionssysteme für CBRNE-Gefahrstoffe«
Karlsruhe, September 2008

World Filtration Congress 2008
Leipzig, April 2008, Exhibitor

Exhibition: Ein mathematisches Kunstbuch – ein künstlerisches Mathematikbuch
August/September 2008

Exhibition: Imaginary – Mit den Augen der Mathematik: 3D-Objekte, virtuelle Welten, interaktive Installationen
April 2008

Cluster-Forum: Simulation in der Werkstofftechnik (togehter with Bayern Innovativ)
Nürnberg, May 2008

Finissage with AtriumJazz
April 2008

Company-Workshops »Load Data Analysis«
DAF, Daimler, MAN, IVECO, SCANIA, VOLVO, Södertälje & Göteborg (S), May 2008; Turin (I), July 2008

Conference »Digitale Nutzfahrzeugtechnologie«
October 2008

Multicore Innovation Workshop
October 2008

Seminar »Lastdaten – Analyse, Bemessung und Simulation«
February 2008

Seminar »Mehrkörpersimulation in der Betriebsfestigkeit«
September 2008

Seminar »Statistische Methoden in der Betriebsfestigkeit«
April & December 2008, VW, Wolfsburg, April 2008

Seminars of the »Simulationszentrums Rheinland-Pfalz« for SME in Rhineland-Palatinate
WFG Südwestpfalz & Zweibrücken, Pirmasens, February 2008; Fraunhofer ITWM, Kaiserslautern, May 2008; Zimmermann Formtechnik, Weilerbach, December 2008

Open house at Fraunhofer ITWM
September 2008

Workshop »Dämmstoffe und Isolationsmaterialien - Design und Charakterisierung«
September 2008

Workshop »Digitale Nutzfahrzeugtechnologie«
John Deere, Mannheim, March 2008

Workshop »Semiinfinite Optimierung«
Klingenmünster, December 2008

Workshop »3d Imaging, Analysis, Modeling and Simulation of Macroscopic Properties«
November 2008

Workshop »Computertomographie und Analyseverfahren für industrielle Anwendungen«
Saarbrücken/Kaiserslautern, March 2008

Guests

Antoulas, Athanasios (International University Bremen und Rice University USA)
Modellreduktion und Systemidentifikation
May 2008

Arnold, Martin (Universität Halle-Wittenberg)
Mehrkörpersimulation – Numerik
March, June & November 2008

Becker, Christoph (Frankfurt School of Finance & Management)
LIBOR Market Model (LMM)
January-December 2008

Bender, Christian (Universität Braunschweig)
True upper bounds for Bermudan products via non-nested Monte-Carlo (lecture)
May 2008

Ciegis, Raimondas (Technical Univ. Vilnius, LT)
Flows in porous media and parallelization
February 2008

Doblare, Manuel (Depto. de Ingeniería Mecánica, University Zaragoza, E)
Biomechanik
November 2008

Eberhard, Peter (Universität Stuttgart)
Numerische Mechanik, MKS, Modellreduktion in mechanischen Systemen
April 2008

Garnier, Josselin (Universität Paris VII, F)
November 2008

Griewank, Andreas (Humboldt-Universität zu Berlin)
Automatische Differentiation und Optimierung
November 2008

Grzibovskis, Richards; Rjasanow, Sergej (Universität des Saarlandes)
Berechnung effektiver elastischer Eigenschaften mit BEM
2008

Hahn, Markus (RICAM Linz, A)
Calibrating Markov Switching Models to Stock Data (lecture)
December 2008

Härdle, Wolfgang (Humboldt-Universität zu Berlin); Spokoiny, Vladimir (WIAS Berlin)
Foundations and Applications of Modern Nonparametric Statistics (Workshop)
May 2008

Hein, Oliver (Frankfurt); Schwind, Michael (TU Kaiserslautern)
Frankfurt Artificial Stock Market (lecture)
January 2008

Hintermüller, Michael (MATHEON Berlin und Universität Graz, A)
Topologieoptimierung
December 2008

Hintze, Michael (Universität Hamburg)
Modellreduktion / POD-Workshop im Rahmen von CAROD
February 2008

Hlod, Andrily
Flow regimes of a viscous jets
November 2008

Jakobsson, Stefan (Fraunhofer-Chalmers Centre, S)
ABB / Rational RBF interpolation for dual patch Antenna data
April, May, June, October, November 2008

Janßen, Rainer (Münchner Rück)
CIO
October 2008

Jenny, Patrick (ETH Zürich, CH)
Multiscale finite volume method, flow in porous media
June 2008

Kaehler, Ben
Pricing American Rainbow Options using Lévy Processes
June-September 2008

Kolymbas, Dimitrios
Bedeutung und Herausforderung der Bodenmechanik
September 2008

Kopfer, Herbert (Universität Bremen)
Kollaborative Transportlogistik / Ansätze zur Effizienzsteigerung in der operativen Transportplanung
January 2008

Lazarov, Raytcho (A&M University, Texas, USA)
Numerical Methods For PDEs
July-August 2008

Mattheij, Bob (TU Eindhoven, NL)
November 2008

Meyer, Arnd (TU Chemnitz)
FE-Strukturmechanik / »FEM for LArge Deformations & Plates«, lecture *ITWM (Seminar MDF)*
March 2008

Meyer, Arndt (TU Chemnitz)
Numerik für Platten- und Schalen
October 2008

Michaelsen, Silke (Hochschule Konstanz)
2D Packungsprobleme im Elektronik-Design
September-December 2008

Mikelic, Andro (Universität Lyon 1, F)
Multiscale problems, homogenization
December 2008

Mikelic, Andro (Université Lyon, F)
Poroelastischer Balken
December 2008

Neuenkirch, Andreas (Universität Frankfurt)
Approximation of SDEs under non-standard assumptions (lecture)
December 2008

Peckham, Natalie (Frankfurt School of Finance & Management)
Latin hypercube sampling with dependence (lecture)
September 2008

Pierdzioch, Christian (Universität Saarbrücken)
Preissetzungsstrategien, Wechselkurse und Aktienmärkte (lecture)
March 2008

Popov, Peter (A&M University, Texas, USA)
Multiscale problems, numerical upscaling, CFD
February 2008

Preusser, Tobias (CeVis, Bremen)
RF-Ablation
October 2008

Ribe, Neil (Institut de Physique du Globe de Paris, F)
Fluid and solid ropes
November 2008

Schmidt, Wolfgang M. (Frankfurt School of Finance & Management)
Default Swaps and Hedging Credit Baskets (lecture)
June 2008

Starikovicius, Vadimas (Technical University, Vilnius, LT)
Numerics for CFD and for flow in porous media
April-June 2008

Stockie, John (Vancouver, CDN)
Brennstoffzellen
January 2008

Tysk, Johan (Universität Uppsala, S)
Bubbles, local martingales and the Black-Scholes equation (lecture)
February 2008

Collaboration in Boards, Editorships

Wardetzky, Max (Universität Göttingen)

Diskrete Differentialgeometrie / »Geometric tools in simulation and optimization of digital surfaces« (lecture ITWM-Seminar)
May 2008

Wunderlich, Ralf (FH Zwickau)

Optimal Portfolio Policies Under Bounded Expected Loss and Partial Information (lecture)
July 2008

Didas, Stephan
- IEEE Transactions on Image Processing (Appraiser)
- Pattern Recognition (Appraiser)

Ettrich, Norman
- Geophysics (Appraiser)
- Geophysical Prospecting (Appraiser)

Günther, Marco
- Fraunhofer-Gesellschaft »Doktorandinnen-Programm« (Appraiser)
- WTR (gewählter Vertreter ITWM)

Hering-Bertram, Martin
- Computer Aided Design (Reviewer)
- EuroVis 2008/ 2009 (Member of committee)
- IEEE Visualization 2008 (Reviewer)
- Topo In Vis 2009 (Member of committee)
- Visualization of Large and Unstructured Data Sets, Lecture Notes in Informatics - Seminars, Gesellschaft für Informatik (GI), 2008 (Editor)

Iliev, Oleg
- Int. J. Heat and Fluid Flow (Appraiser)
- J. Comp. Meth. Appl. Math. (Editor)
- J.Food Engineering (Appraiser)
- LNCS, Springer (Appraiser)
- Math. Modelling and Analysis (Editor)
- Member of the Interim Management Board of the International Society for Porous Media
- SIAM J. Sci. Comp. (Appraiser)
- Tranport in Porous Media (Appraiser)

Korn, Ralf
- Advances in Applied Probability (Assoc. Editor)
- Blätter der DGVFM (Editorial Board)
- Dekan des Fachbereichs Mathematik der TU Kaiserslautern
- Mathematical Finance (Associate Editor)
- Mathematical Methods of Operations Research (Associate Editor)
- Mitglied des Senats der TU Kaiserslautern
- Mitglied des Verwaltungsrats der Assenagon Asset Management SA
- Sprecher Landesexzellenzcluster DASMOD
- Sprecher Landesforschungszentrum $(CM)^2$
- Stellvertretender Vorsitzender der Deutschen Gesellschaft für Versicherungs- und Finanzmathematik

Küfer, Karl-Heinz
- Mathematical Programming (Appraiser)
- Mathematics of Operations Research (Appraiser)
- Medical Physics (Appraiser)
- Zentralblatt für Mathematik (Reviewer)

Maasland, Mark
- Fraunhofer Allianz Vision (Member)

Mohring, Jan
- VDI/VDE-Gesellschaft Mess- und Automatisierungstechnik, GMA (Member)

Müller, Marlene
- Computational Statistics (Associate Editor)
- Computers & Operations Research (Appraiser)
- Elected Member of the International Statistical Institute (ISI)
- Mitglied des Ausschuss für Ökonometrie des Vereins für Socialpolitik

Neunzert, Helmut
- European Journal of Applied Mathematics (Associate Editor)
- Evaluierungskommission für das Dep. of Physics and Mathematics, University of Lund
- Fraunhofer-Chalmers Research Centre for Industrial Mathematics FCC (Vice Chairman of the Board)
- Monte Carlo Methods and Application (Associate Editor)
- Technologie-Beirat der Stadt Kaiserslautern
- Technologie-Botschafter der Stadt und des Landkreises Kaiserslautern

Nickel, Stefan
- Annals of OR (Appraiser)
- Centro de Investigação Operacional da Fundação da Faculdade de Ciências da Universidade de Lisboa (Member Advisory Board)
- Computers & Operations Research (Editor in Chief)
- European Journal of Operational Research (Appraiser)
- European Working Group on Locational Analysis (EWGLA) (Speaker of the Board)
- GOR (Member Advisory Board)
- GOR Arbeitsgruppe »Health Care Management« (Chairman)
- Health Care Management Science (Member Editorial Board)
- IEEE Transactions (Appraiser)

- Mathematical Programming (Appraiser)
- Mathematical Reviews (Reviewer)
- Networks (Appraiser)
- Omega (Appraiser)
- Operations Research Letters (Associate Editor)
- OR Spectrum (Appraiser)
- Zentralblatt für Mathematik (Reviewer)

Prätzel-Wolters, Dieter
- Forschungszentrum »Center of Mathematical and Computational Modeling CM²« der TU Kaiserslautern (Member)
- Fraunhofer-Chalmers Research Centre for Industrial Mathematics FCC (Boardmember)
- GAMM-Fachausschuss »Dynamik und Regelungstheorie (Member)
- Graduiertenkolleg »Mathematik und Praxis« der Technischen Universität Kaiserslautern (Member)
- Präsidium und Senat der Fraunhofer-Gesellschaft (Member)
- Rheinland-pfälzischer Landesforschungsschwerpunkt »Mathematik und Praxis« (Member)
- Stiftungsrat »Fraunhofer Zukunftsstiftung« (Member)
- Wissenschaftlich-technischer Rat und Hauptkommission der Fraunhofer-Gesellschaft (Chairman)

Redenbach, Claudia
- Communications in Statistics - Theory and Methods (Appraiser)
- Image Analysis & Stereology (Appraiser)

Rieder, Hans
- VDE/VDI-Fachausschuss »Nichtlineare Systeme«

Rösch, Ronald
- Commercial Vehicle Cluster (CVC)
- Deutsche Gesellschaft für Materialkunde e. V. (DGM, Member)
- Deutsche Gesellschaft für Zerstörungsfreie Prüfung e. V. (DGZfP, Member)
- DGM-Arbeitskreis »Quantitative 3D-Mikroskopie«
- DGM-Arbeitskreis »Tomographie«
- DGM-Fachausschuss »Strahllinien«
- Fraunhofer Allianz Vision (Member)
- Fraunhofer-Innovationsthema Leichtbau (ILBS)
- Heidelberger Bildverarbeitungsforum (Advisory Board)
- IOP electronic Journals (Appraiser)

Scherrer, Alexander
- Physics in Medicine and Biology (Appraiser)

Schladitz, Katja
- Image Analysis & Stereology (Editorial Board)
- Journal of Microscopy (Appraiser)
- Journal of the Royal Statistical Society (Appraiser)
- Leichtbau-Cluster (Member)

Schröder, Michael
- Computers & Operations Research (Appraiser)

Siedow, Norbert
- HVG-DGG (Member): AIF Beraterkreis »Verteilerrinne«

Spies, Martin
- Acustica (Appraiser)
- IEEE Transactions on Ultrasonics, Ferroelectrics & Frequency Control (Appraiser)
- Journal of Computational Acoustics (Appraiser)
- Journal of the Acoustical Society of America (Appraiser)
- Materials Evaluation (Appraiser)
- NDT&E International (Appraiser)
- Ultrasonics (Appraiser)
- Wave Motion (Appraiser)

Wenzel, Jörg
- Mathematical Reviews (Appraiser)
- Zentralblatt der Mathematik (Reviewer)

Zemitis, Aivars
- Mathematical Modelling and Analysis ‚The Baltic Journal on Mathematical Applications, Numerical Analysis and Differential Equations (Editor)

Dalheimer, Mathias; Pfreundt, Franz-Josef

Rechneranordnung mit automatisierter Zugriffssteuerung von einer und Zugriffskontrolle auf eine Applikation sowie entsprechendes Zugriffssteuerungs- und Zugriffskontrollverfahren

Deutsche Anmeldung Nr. 102008034492.3

Dreßler, Klaus; Bitsch, Gerd

Verfahren zur Bestimmung von Kenngrößen für die Auslegung eines Bauteils und Vorrichtung enthaltend ein derartiges Bauteil

Europäische Anmeldung Nr. 08004814.3

Lojewski, Carsten

Verfahren zur computergestützten Identifikation der von einem Richtstrahl durchschnittenen Kinderoktanten eines Elternoktants in einer Octree-Datenstruktur mittels Look-up-Tabellen

Deutsches Patent Nr. 102006061325 B4

Trinkaus, Hans; Küfer, Karl-Heinz

Vorbereiten einer Auswahl von Steuergrößen für eine einzustellende Dosisverteilung eines technischen Gerätes

US-Patent Nr. 7391026 B2